DRAFT

IMPLEMENTATION PLAN FOR

REGIONAL COMMUNICATION STRATEGIC INVESTMENT PLAN

MAY 28, 2019

METROPOLITAN TRANSPORTATION COMMISSION

Kimley»Horn
Expect More. Experience Better.

Contents

GLOSSARY OF TERMS

***CMS* –** Changeable Messages Sign

***C/CAG* –** City/County Association of Governments of San Mateo County

DSRC – Dedicated Short Range Communications

FCC – Federal Communications Commission

HDPE – High-Density Polyethylene

HOV – High-Occupancy Vehicle

CCTV –Closed-Circuit Television Cameras

ITS – Intelligent Transportation Systems

Kbps – Kilobits per Second.

LPR – License Plate Reader

Mbps – Megabits per Second

OBU – Onboard Unit

PE – Preliminary Engineering

RCN – Regional Communications Network (as defined in Section 1.4)

RSU – Roadside Unit

SMFO – Single-mode Fiber Optic Cable

TOS – Traffic Operations Systems

TMS – Transportation Management Systems

V2I – Vehicle-to-Infrastructure

V2V – Vehicle-to-Vehicle

VOD – Vehicle Occupancy Detection

1. INTRODUCTION

The Metropolitan Transportation Commission (MTC) intends to assist in the development of a robust and reliable regional communications network that will enable data and information sharing and facilitate the implementation of technology-based congestion management strategies focused on enhancing the livability and economic vitality of communities through the nine-county Bay Area.

1.1 Project Background

In 2003, Caltrans District 4 and MTC collaborated on the development of a Traffic Operations System (TOS) Implementation Plan. This document presented an assessment of existing, planned, and programmed regional field device coverage on the 500-mile freeway network. Using a Systems Engineering approach to define overall system architecture and functional requirements of the TOS network, a strategy was outlined for expanding and implementing a communications infrastructure to support the TOS elements. Each segment of the freeway network was prioritized based on bandwidth needs, gap closures, cost-benefit considerations, and other needs at the time.

In 2009, the document was updated and titled Bay Area Regional Communications Plan. The focus was on identifying strategies to upgrade or enhance the communications network to expand and accommodate the Caltrans' video system, as well as other field devices. The document captured an analysis of bandwidth needs for each corridor and a cost analysis for using agency-owned or leased communications. Projects and corridors were prioritized based on cost benefits (e.g., elimination of monthly recurring leased costs), functionality provided by each alternative, and corridors of regional significance.

In 2013, the Bay Area Regional Communications Plan was updated to factor in additional programs (Express Lanes, Integrated Corridor Management, Freeway Performance Initiative), and to consider new priorities from local and regional stakeholders throughout the Bay Area. This Plan introduced a "Regional Communication Fiber Ring" around the San Francisco Bay Area, aimed to reduce lease-line recurring costs, upgrade existing infrastructure and share data among agencies.

The Bay Area Regional Communications Plan is now being updated to create a Regional Communication Strategic Investment Plan. This project will propose projects and create a roadmap for future investments. It will enable MTC, Caltrans, and other regional stakeholders to develop a regional communications network which will provide a foundation of shared infrastructure. This foundation can potentially support projects like managed lanes, ICM, Smart Cities, and other advanced technologies to come.

1.2 Roles and Responsibilities

The Plan lays out the purpose and need for the regional communications network, as well as roles and responsibilities of participating agencies. Development and maintenance of the Plan is currently MTC's responsibility. Plan implementation, in using this document as guidance in creating a regional communications network, will be the responsibility of all agencies that intend to participate in the network. Participating agencies may use this document to identify needs for additional communications infrastructure in their jurisdiction. Participation is not mandated.

1.3 Project Vision Statement, Goals, and Objectives

On September 20, 2018 MTC hosted a stakeholder workshop to discuss the project purpose, stakeholder roles and responsibilities, and project goals and objectives. Following the meeting, MTC solicited input from stakeholders to help develop a vision statement, goals, and objectives for the Plan. The second stakeholder meeting on January 31, 2019 further shaped these three elements. The results of that input were used to develop the final vision statement and plan objectives, presented below, that have been used to guide subsequent development of various aspects of the strategic investment plans.

The vision statement of the Bay Area Regional Communication Strategic Investment Plan is:

> *To provide the technical and policy framework to develop a fast, reliable, redundant, and cost-effective regional communications network that will enable the sharing of data, infrastructure, and maintenance costs among project partners; support coordinated and interoperable transportation systems across multiple jurisdictions; and facilitate technology-based strategies focused on enhancing safety, mobility, livability and economic vitality of communities throughout the nine-county San Francisco Bay Area.*

Below are the goals and objectives for the Bay Area Regional Communication Strategic Investment Plan as developed by stakeholders.

- **Goal 1:** Identify projects to establish a high-bandwidth, reliable, and redundant regional communications network through the nine-county San Francisco Bay Area.
    - Objective 1-1: Identify projects that complete a redundant regional communications backbone along routes surrounding the San Francisco Bay.
    - Objective 1-2: Identify projects that connect the regional communications network to multiple Internet points-of-presence (POPs) throughout the region to support broadband connectivity to participating agencies.
    - Objective 1-3: Identify projects that complete the connection between regional communications network and express lane operators throughout the nine-county San Francisco Bay Area.
- **Goal 2:** Develop policies and strategies that encourage agencies to connect their local networks to the regional communications network.
    - Objective 2-1: Develop policy and Partnership MOU for use of and access to the network.
    - Objective 2-2: Develop strategy for shared funding (capital and O&M).
    - Objective 2-3: Develop requirements for regional communications network infrastructure.
- **Goal 3:** Facilitate development of best practices for procuring, implementing, and maintaining communications network infrastructure.
    - Objective 3-1: Develop initial procurement strategies for procurement of regional communications network equipment including shared procurement options and regionally negotiated pricing and warranties.
    - Objective 3-2: Develop best practices for implementation and maintenance of various communications media for use by partner agencies.
- **Goal 4:** Encourage the sharing of existing agency-owned infrastructure to provide secure and reliable communications for transportation agencies in the region.
    - Objective 4-1: Identify projects and opportunities to use existing communications infrastructure to complete regional communications network objectives.
    - Objective 4-2: Identify projects that complete connections between key transportation agency facilities and the proposed regional communications network.

The Regional Communications Strategic Investment Plan consists of five main tasks. The five tasks are listed below:

1. Documentation of Existing and Planned Communications Infrastructure and Capacity
2. Implementation Plan
3. Cost/Benefit Analysis
4. Communication Infrastructure Sharing
5. Regional Communication Strategic Investment Plan

This document fulfills the second task – the Implementation Plan. The Implementation Plan is organized into the following sections:

- *Existing Conditions and Planned Projects*:
  This section includes the results of the first task of the Regional Communications Strategic Investment Plan - a summary of fiber communications projects and infrastructure that are existing or planned as provided by project stakeholders. The purpose of this section is to capture any existing or planned projects that could play a role in, or be a part of, a future regional communications network.

- *Proposed Projects:*
  Based on the review of existing conditions and planned projects, this section provides information about additional recommended projects proposed to close identified communications gaps. In addition to providing information about how these gap closure projects were selected, this section provides information about how each of these projects meets the plan objectives defined by stakeholders. Currently, the proposed projects are not linked to specific funding sources.

- *Communications Technology Evaluation:*
  This section focuses on an evaluation of different communications technologies applicable to proposed projects. The evaluation includes research about the different types of technologies, a discussion about the communications technologies of the future, methodology for selecting the most appropriate technology for each gap closure project, and results of the technology evaluation. The technology evaluation results are followed by a full build out map of the regional communications network.

- *Cost Analysis/Funding Plan Options:*
  After determining the most appropriate communications technology for each gap closure project, this section provides detailed information about the cost to implement each project. The cost analysis includes capital costs of projects, a discussion about return on investment of fiber communications infrastructure installation as well as project costs by phase (PE, R/W, etc.). In addition to project cost information, this section also includes a discussion of different funding sources that can be used to pay for proposed projects. The results of this section will provide the basis for Task 3 of the Regional Communications Strategic Investment Plan.

- *Project Prioritization:*
  The final section in this document provides information about how each gap closure project is prioritized. This section includes a detailed breakdown of the methodology for evaluating each project. Additionally, this section provides information about estimated project construction timelines.

The Implementation Plan and its components, such as the project list, are living documents and can be updated or reprioritized based on stakeholder input. The results of this document will be summarized in the Final Regional Communications Strategic Investment Plan.

1.4 Key Terms

For the purposes of this Plan the terms listed below will be defined as follows:

- Project Team or Team – Kimley-Horn.
- Regional Communications Network – Communications infrastructure dedicated to regional data sharing purposes. Transfer of select agency data that meets the goals of this Plan would occur over this network. Owning agencies will have full autonomy over which of their data is shared.
- Regional Fiber Backbone – Communications network fiber backbone along routes surrounding the San Francisco Bay Area. This enables redundant connectivity throughout the Bay Area.
- Gap Closure – Gaps represent missing portions of the Regional Communications Network that are required to create a continuous network. Proposed gap closure projects close those gaps with the intent of creating a continuous network to achieve the goals and objectives of the Plan.

2. EXISTING CONDITIONS AND PLANNED PROJECTS

For the implementation plan, the project team compiled documentation of existing and planned communications infrastructure and capacity, which revealed existing gaps in the future regional communications network. These gaps were combined into recommended projects, then prioritized based on their proposed technology, planning-level costs, and ease of implementation in subsequent sections of the document.

The purpose of this section is to present an inventory of existing communications infrastructure. While extensive infrastructure is being reflected in this document, some infrastructure may not be included in a proposed project or relevant to the rest of the report.

Existing and Planned infrastructure data is presented in this section by sub-region. For the purposes of this project, the nine-county Bay Area has been divided into four sub-regions:

- Peninsula (San Francisco and San Mateo Counties)
- South Bay (Santa Clara County)
- East Bay (Alameda and Contra Costa Counties)
- Solano-North Bay (Solano, Sonoma, Napa, and Marin Counties)

2.1 Existing Infrastructure/Projects

The following is a summary discussion of existing regional communications infrastructure and corresponding projects of regional significance. Existing projects are either already built or are under construction and expected to be completed in the next 2-3 years. Figure 1 provides an overview summary of existing regional fiber communications infrastructure (conduit with fiber). Figure 2 provides an overview of existing regional conduit infrastructure (conduit with and without fiber).

2.1.1 Peninsula

Existing regional communications infrastructure within the Peninsula sub-region consists of approximately 20 miles of conduit and fiber along El Camino Real (SR 82) between San Bruno and Palo Alto, and several miles of fiber along Caltrain's right-of-way. The El Camino Real network consists of a 72-strand SMFO cable installed in a multi-conduit duct bank. There is also a segment of 72-strand SMFO cable that ties the El Camino Real segment to signals along SR 84/Marsh Road via US 101.

The existing communications infrastructure described above serves the C/CAG US 101 Smart Corridor network. The objective of this network is to allow partner agencies in San Mateo County access to real-time traffic data along the corridor for local day-to-day traffic management, as well as regional traffic management during major incidents along US 101. Most of the Smart Corridor fiber is installed along El Camino Real and Bayfront Expressway, within Caltrans right-of-way.

2.1.2 South Bay

Existing regional communications infrastructure within the South Bay sub-region consists of fiber cable and conduit on portions of US 101 and El Camino Real installed by VTA and Caltrans. As part of the I-880 HOV Widening Project, communications conduits were installed on I-880 between SR 237 and US 101.

In addition, many local principal arterials, and almost all the expressways have fiber communications infrastructure installed. The local fiber installations are primarily owned and maintained by the City of San

Jose and City of Santa Clara for city-owned traffic signal communications. The County of Santa Clara's infrastructure is used for similar purposes along the expressways.

A large portion of the existing fiber communications network in the South Bay was installed by the Silicon Valley – ITS (SV-ITS) program as a traffic management strategy. This program is a regional resource to allow communications between the Cities of San Jose, Fremont, Milpitas, Cupertino, Campbell, Santa Clara, the Town of Los Gatos, Santa Clara County, and Caltrans.

2.1.3 East Bay

Existing regional communications infrastructure within the East Bay sub-region consists of Caltrans fiber cable and conduit along I-580, I-680, and I-880 in addition to some local fiber in the Cities of Dublin, Pleasanton, Livermore, Hayward, San Leandro, Oakland, Berkeley, Emeryville, Union City, and Fremont.

The I-680 corridor includes a 144-strand SMFO cable installed in a 1 to 4-3 inch conduit duct bank. The communications infrastructure is installed between the I-580/I-680 interchange in Dublin, and the Benicia Bridge Toll Plaza in Martinez, approximately 27 miles. The I-680 Sunol Express Lanes project currently operates wireless communications on its southbound lanes (SR 84 to SR 262) but the northbound I-680 express lane will convert that to fiber for both directions.

The I-880 communications infrastructure includes a 288-strand SMFO cable installed in a 3-3-inch or 4-1.5 inch multi-conduit duct bank. The fiber infrastructure is installed between Hegenberger Road in Oakland, and Dixon Landing Road in Milpitas, approximately 26 miles.

The I-680 and I-880 corridors include existing regional express lane operations. The fiber communication network is maintained by BAIFA on both existing corridors. However, the conduit infrastructure is owned by Caltrans, and is installed in Caltrans' right-of-way. Caltrans also owns 72 strands of the fiber cable along both corridors.

The I-580 corridor includes regional express lane operation. The I-580 infrastructure runs between the I-580/I-680 interchange in Dublin, and Greenville Road in Livermore, approximately 12 miles. It includes one 1.5-inch conduit with a 72-strand SMFO cable owned by Alameda County Transportation Commission (Alameda CTC), one 1.5-inch conduit with a 72-strand SMFO cable owned by Caltrans, two 1.5-inch empty conduits and one empty 3-inch conduit with pull tape for use by Caltrans. The express lanes and fiber communication network are maintained by Alameda CTC. The conduit infrastructure is owned by Caltrans.

There are several local streets with fiber communications infrastructure throughout Dublin, Livermore, and Pleasanton which were installed as part of the I-580 Smart Corridor Project. The City of Dublin owns140-strand SMFO fiber which is installed along Dublin Boulevard between San Ramon Road in Pleasanton and Fallon Rd in Dublin which runs parallel to I-580 and intersects with I-680.

There is also City-owned fiber communications infrastructure installed throughout Hayward, San Leandro, Oakland, and Fremont. Fiber communications infrastructure was installed in Oakland along San Pablo Avenue from 14th St to MacArthur Boulevard as part of the I-80 Integrated Corridor Management project.

2.1.4 Solano-North Bay

There is currently empty conduit infrastructure in Marin County in two stretches along US 101. Along US 101 through the City of San Rafael there is nearly four miles of two 1.25" empty conduits. Through the City of Novato there are four 1.5" empty conduits for nearly three miles along US 101.

2.1.5 Regional Communications Infrastructure

Throughout the nine-county Bay Area there are 17 BayLoop Microwave sites owned and operated by the Bay Area Regional Interoperable Communications Systems Authority (BayRICS). These microwave sites make up a high-capacity network originally created to support public safety services. This is an existing communications network with locations throughout the Bay Area that is led by an inter-agency Joint Powers Authority.

BART has installed fiber communications infrastructure along their right-of-way throughout the Bay Area. Caltrans has 16 access points to BART fiber strands. The City of San Jose, City of San Francisco, City of Oakland, and the City of Dublin also have connections to BART fiber communications infrastructure.

Caltrain has a Positive Train Control Project that aims to electrify the Caltrain transit line. Caltrain right-of-way/infrastructure is currently the most available alignment for shared infrastructure, but other systems like the possible High Speed Rail alignment may be additional sources as the opportunities arise in the future.

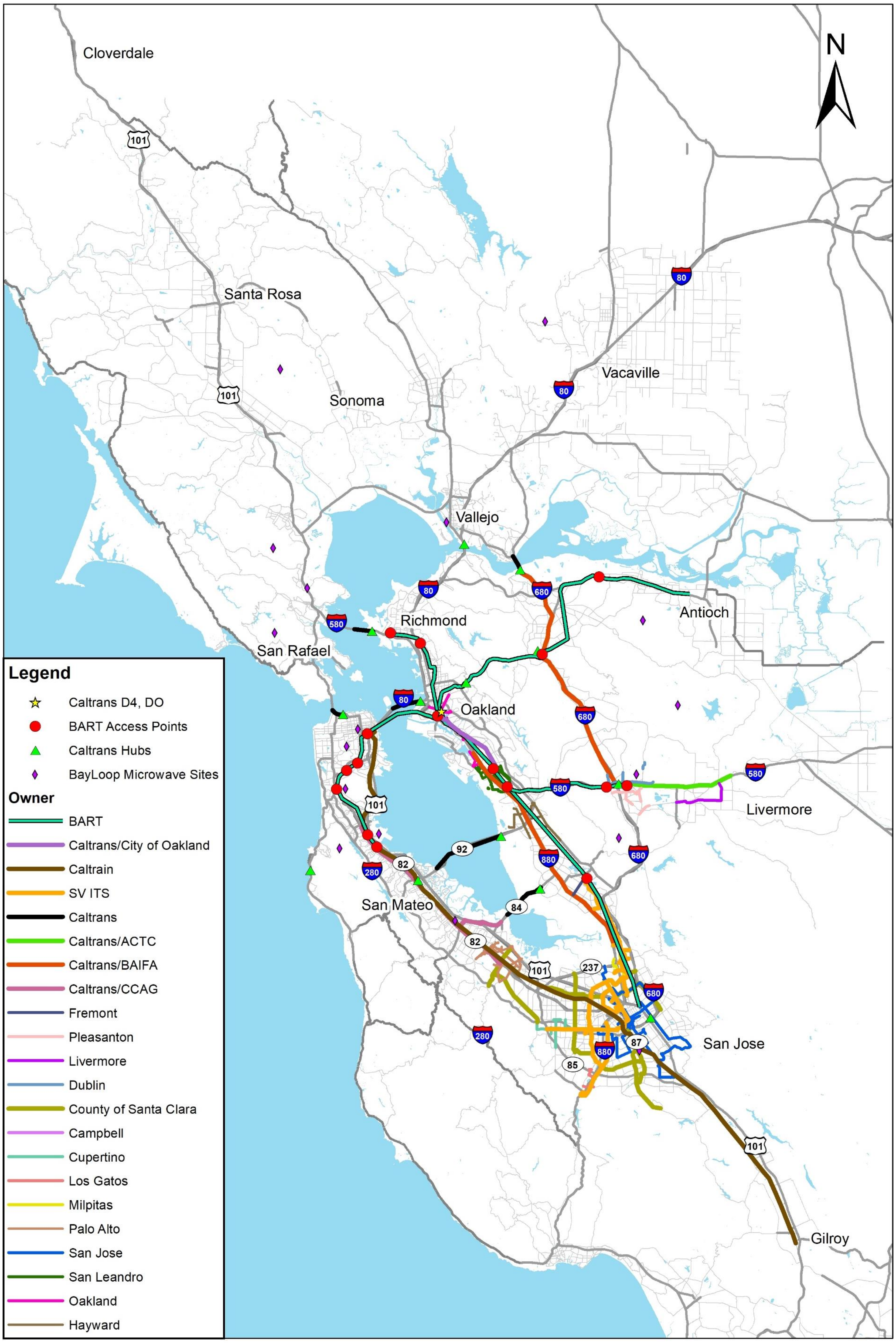

Figure 1: Existing Regional Fiber Communications Infrastructure

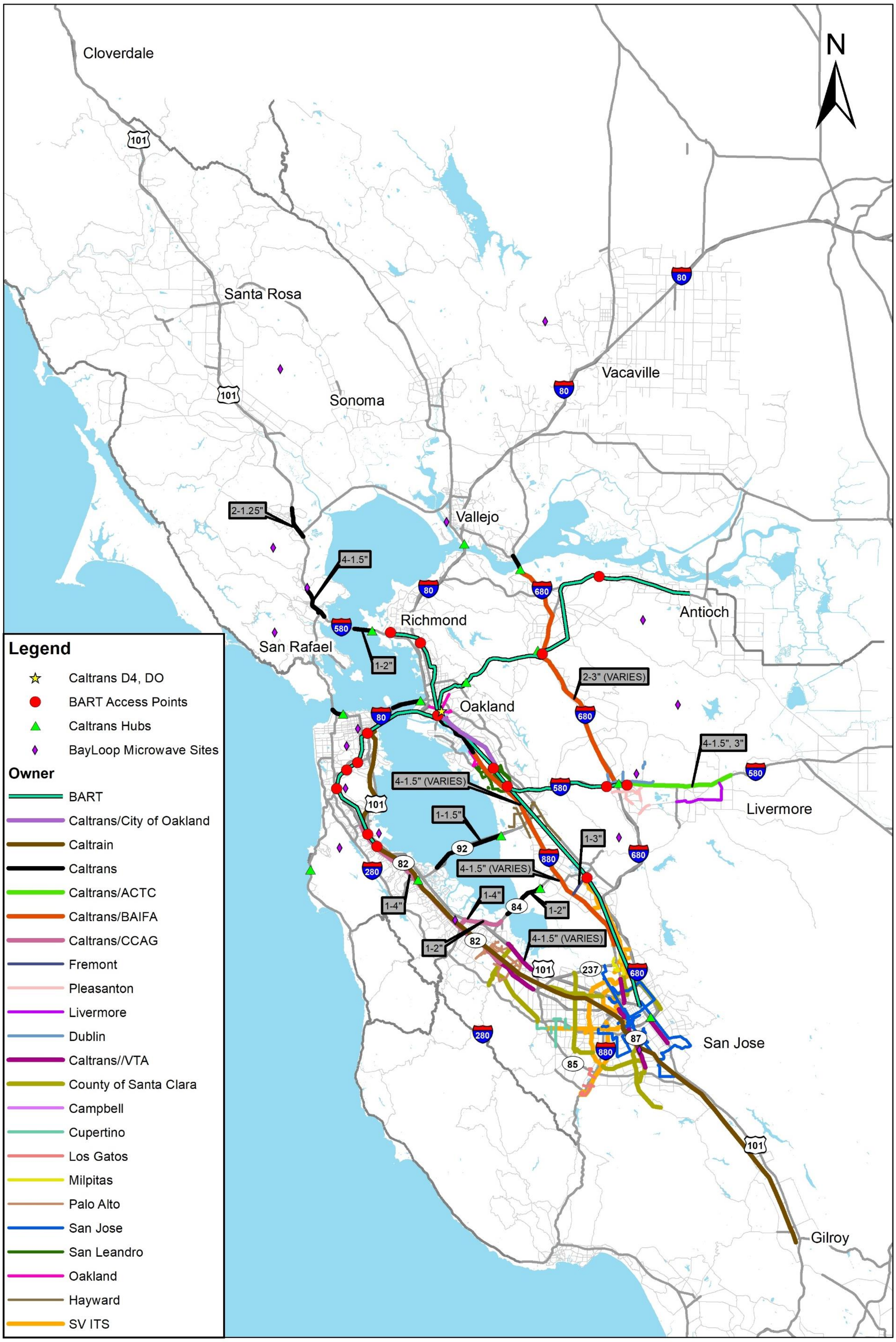

Figure 2: Existing Regional Conduit Infrastructure

2.2 Planned Infrastructure/Projects

The following is a summary of planned regional communications infrastructure and corresponding projects of regional significance that may be implemented within the next five years. Most of the planned infrastructure is not currently funded. Figure 3 provides an overview summary of planned regional communications infrastructure.

2.2.1 Peninsula

There are three planned regional communications infrastructure projects on the peninsula. All projects entail installation of fiber. One project is planned along US 101 between Embarcadero Road in Palo Alto and Grand Avenue in South San Francisco. The other project will be along Airport Boulevard and Gateway Boulevard in South San Francisco. The third project will be along various routes parallel to I-280 in South San Francisco and Daly City. All projects will be administered by C/CAG in partnership with Caltrans. The US 101 communications infrastructure will facilitate new regional express lane implementation and separate communications to Caltrans' freeway TMS elements; the fiber infrastructure in South San Francisco and Daly City will facilitate implementation of Smart Corridor projects.

2.2.2 South Bay

Four near-term freeway projects in the South Bay could provide a possible opportunity to build out portions of the regional communications network. The four projects are being administered by VTA as part of the express lanes on SR 237, SR-85 and US 101. Fiber communications are also planned to support Caltrans' freeway TMS elements along these corridors.

2.2.3 East Bay

There are several planned regional communications infrastructure expansions in the East Bay. The I-880 Integrated Corridor Management (ICM) Central Segment, is being administered by MTC and extends the existing I-880 ICM Project from Davis Street in San Leandro to Whipple Road in Union City.

As previously mentioned, the I-680 Sunol Express Lanes project is expanding to the northbound lanes along the existing project limits. In addition to this expansion, the project intends to add one 72-strand SMFO cable along I-680 from SR 262 to SR 84 in a 4-inch conduit with three 1-inch diameter high density polyethylene (HDPE) innerducts, two of which will be left empty to be used in the future. There is an additional project, planned to complete the I-680 Sunol Express Lanes between SR 84 and Alcosta Boulevard in San Ramon.

CCTA is working on a series of projects they have combined under one large 7-step initiative called "Innovate 680." The first step in the Innovate 680 project is to close the existing HOV gap and complete the express lanes network along I-680 in Contra Costa County. Steps 2-7 include various strategies to address bottlenecks in the corridor, improve transit service, update existing ITS equipment, and ultimately prepare the corridor for the future.

There are also several planned projects on local routes. The City of Oakland MacArthur Smart Corridor will be an innovative incident management corridor parallel to I-580. The City intends to install fiber along MacArthur Boulevard from I-580 in San Leandro to City Hall in downtown Oakland. The anticipated project completion is 2021.

MTC is implementing the I-880 integrated corridor management (ICM) project. Most signals along the corridors have fiber or copper interconnect currently and the project plans to fill the gaps in existing communications infrastructure. The San Pablo Avenue Corridor Project is an ICM project implemented by

Alameda CTC. It is relieving congestion on I-80 by improving operations along San Pablo Avenue from Oakland to San Pablo.

2.2.4 Solano-North Bay

There is a planned express lanes project that has fiber communications infrastructure in Solano County. That project will be administered by the Solano Transportation Authority. The planned project is an express lanes implementation along I-80 between the I-80/I-680 junction in Fairfield, and the I-80/I-505 interchange in Vacaville, approximately 17 miles. This project is anticipated to include installation of fiber conduit and cable from Manual Campos Parkway in Fairfield to Leisure Town Road in Vacaville.

The Napa Valley Transportation Authority is currently planning to build a managed lane along SR 37 between SR 121 and the West span of the Napa River as part of the State Route 37 Resilient Corridor Program. A contraflow lane and shoulder running lane are being considered as managed lane options.

The Transportation Authority of Marin has identified several projects to be considered for Regional Measure 3 funding. The US 101/I-580 Direct Connector Project is planned to include installation of fiber communications infrastructure along Sir Francis Drake Blvd between the two highways.

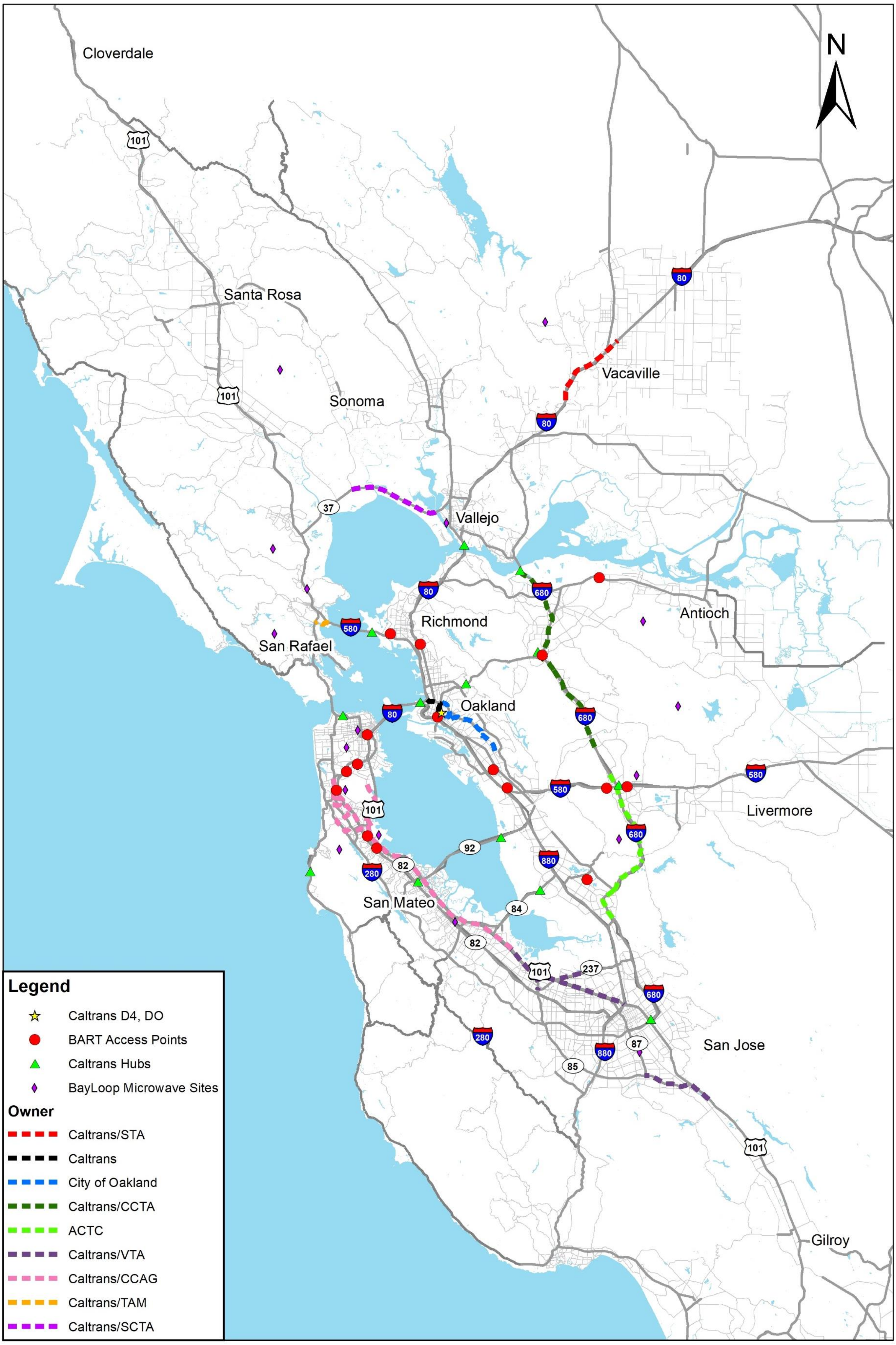

Figure 3: Planned Regional Fiber Communications Infrastructure

3 PROPOSED PROJECTS

After reviewing and summarizing existing and planned communications infrastructure in the region, the team identified gaps where the infrastructure does not meet the regional communication objectives as determined by stakeholders. The communications infrastructure gap projects were identified through a selection methodology developed by the project team. This methodology is described in detail in the sections below. A resulting list of gap closure projects is provided as recommendations to further develop the regional communications network. This list is not exhaustive and is subject to updates based on stakeholder input.

Currently there are no communications dedicated for regional data transfer so there is no existing regional communications network. There are opportunities to create a regional communications network based on sharing existing and planned communications infrastructure. To leverage existing and planned investments, some proposed projects suggest sharing communications infrastructure. It is assumed that the regional communications network will have its own active electronics and will not include laterals to TMS equipment.

While the main goal of this Plan is to exchange data between agencies, all reference to sharing in the context of a proposed project refers to sharing communications infrastructure and not sharing data. Collection of data would occur on agency's communications network and sharing data would occur through the regional communications network. Owning agencies will have full autonomy over what data is shared. Network security will not be discussed in this document because networks are secured on a design level.

3.1 Local Agency Use Cases

Although the focus of the project is technically to develop a regional communications network, there are also opportunities for local agencies to benefit from a regional network. Some potential use cases include:

- Accessing traffic management data and information such as CCTV camera feeds and traffic signal timing with adjacent agencies along a corridor
- Interoperability of transportation system operations for shared control, back-up control, integrated corridor management, and/or after-hours control as desired (only where desired by participating agencies)
- More consistent and reliable communications during major incidents, emergencies, and natural disasters
- Access to a regional performance measures dashboard for arterial performance
- Opportunity to integrate local transportation management strategies with regional strategies
- Development of a robust multi-use network that provides enhanced security over a single-agency infrastructure

The following section describes how the Project Team proposes the regional communications network is built out.

3.2 Project Development Methodology

There are several Plan objectives that relate to identifying projects. They are as follows:

- <u>Objective 1-1:</u> Identify projects that complete a redundant regional communications backbone along routes surrounding the San Francisco Bay.

- Objective 1-2: Identify projects that connect the regional communications network to multiple Internet points-of-presence (POPs) throughout the region to support broadband connectivity to participating agencies.
- Objective 1-3: Identify projects that complete the connection between regional communications network and express lane operators throughout the nine-county San Francisco Bay Area.
- Objective 4-2: Identify projects that complete connections between key transportation agency facilities and the proposed regional communications network.

Table 1 relates a proposed project type to each objective related to identifying projects.

Table 1: Objective and Project Type

Objective #	Objective	Proposed Project Type
1-1	Identify projects that complete a redundant regional communications backbone along routes surrounding the San Francisco Bay.	-Install and share communications infrastructure to complete the regional communications network around the San Francisco Bay Area. - Install and share communications infrastructure along the San Mateo and Dumbarton bridges to create redundant loops.
1-2	Identify projects that connect the regional communications network to multiple Internet points-of-presence (POPs) throughout the region to support broadband connectivity to participating agencies.	- Install and share communications infrastructure to connect POPs to the regional communications network
1-3	Identify projects that complete the connection between regional communications network and express lane operators throughout the nine-county San Francisco Bay Area.	- Install and share communications infrastructure to connect express lanes to the regional communications network
4-2	Identify projects that complete connections between key transportation agency facilities and the proposed regional communications network.	- Install and share communications infrastructure to connect transportation centers to the regional communications network

Based these objectives, specific projects are identified as part of the Regional Communications Strategic Investment Plan.

3.2.1 Completing the Regional Communications Backbone

To meet Objective 1-1 of completing the regional communications backbone around the Bay Area, three types of projects are being recommended: share existing fiber communications, share planned fiber communications, and install new communications. Infrastructure is necessary along stretches of SR 237, US 101, I-80, and I-880 to complete the regional communications network.

The identified gaps in the regional communications backbone for which installing new communications infrastructure was recommended includes:

- US 101 from the San Francisco County Line to the I-80/US 101 interchange
- I-80 from the I-80/US 101 interchange to Yerba Buena Island
- I-80 from the Bay Bridge Toll Plaza to the I-80/I-880 interchange
- I-880 from the I-80/I-880 interchange to Hegenberger Road, Oakland
- I-880 from Dixon Landing Road, Milpitas to the I-880/SR 237 interchange
- SR 237 from the I-880/SR 237 interchange to North 1st Street, San Jose

The identified gaps in the regional communications backbone for which sharing conduit infrastructure was recommended includes:

- I-80 from Yerba Buena Island to the Bay Bridge Toll Plaza

The identified gaps in the regional communications backbone for which dedicated existing fiber strands is recommended includes:

- I-880 from Hegenberger Road, Oakland to Dixon Landing Road, Milpitas
- US 101 from Embarcadero Road, Palo Alto to Grand Avenue, South San Francisco
- US 101 from the US 101/SR 237 interchange to Embarcadero Road, Palo Alto
- SR 237 from North 1st Street, San Jose to the US 101/SR 237 interchange

Figure 4 summarizes the proposed projects necessary to complete the regional communications backbone around the Bay Area only. This is figure does not include all proposed projects or all existing infrastructure, which will be presented throughout the rest of this document.

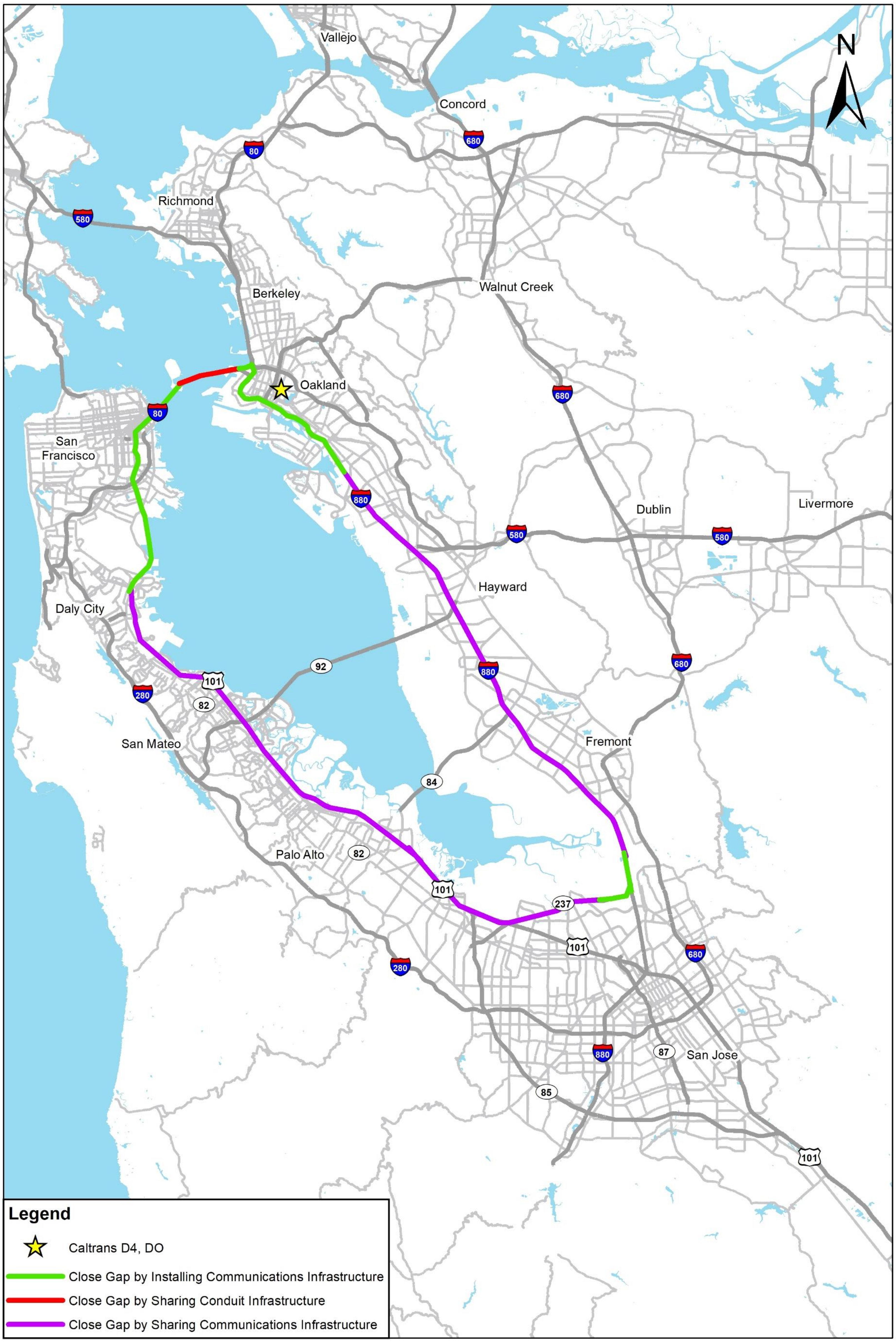

Figure 4: Regional Communications Backbone

To create redundant connections for the regional communications backbone it is recommended to share conduit infrastructure with Caltrans across the following regional bridges:

- San Mateo Bridge (SR 92 from US 101 to I-880)
- Dumbarton Bridge (SR 84 from US 101 to I-880)

These two proposed projects include installing new fiber strands in the existing conduit infrastructure. Caltrans is in the process of confirming whether their existing conduit has capacity for new fiber strands. They also require installing new communications infrastructure on the Eastern and Western sides of the bridges to connect them to I-880 and US 101 respectively.

3.2.2 Connecting POPs to Regional Communications Network

To achieve the Objective 1-2 of connecting the regional communications network to Internet Points-of-presence (POP) throughout the Region, it is recommended to install new communications infrastructure and connect several data centers in the region. These connections could potentially enable participating agencies to have Internet access. The proposed project list is not exhaustive as it can include any POP in the nine-county Bay Area. Digital Realty was chosen as an example, not an implied recommendation, because the City of Oakland is connected to a Digital Realty data center and they have locations throughout the Bay Area. The City of San Jose is connected to a Regional internet service provider (ISP) in San Jose that could potentially serve as a POP.

There are two proposed projects that include installing new communications infrastructure to Digital Realty data centers throughout the Bay Area. These include:

- Digital Realty at 720 2nd St, Oakland, CA 94607
- Digital Realty at 200 Paul Ave, San Francisco, CA 94124

There is one proposed project that includes sharing communications infrastructure to connect a data center to the regional communications network:

- Digital Realty at 3205 Alfred St, Santa Clara, CA 95054

3.2.3 Connecting to Express Lanes to Regional Communications Network

To achieve the Objective 1-3 of connecting the regional communications network to express lanes throughout the Region, it is recommended to install new communications infrastructure and connect the following existing and proposed express lanes to the regional communications network:

- SR 85 in Santa Clara County (VTA)
- I-580 in Alameda County (Alameda CTC)
- I-680 in Alameda County (Alameda CTC)
- I-680 in Contra Costa County (CCTA)
- SR 37 in Sonoma and Solano Counties (MTC)
- I-80 in Solano County (STA)

Express lane projects along the proposed regional communications network backbone do not need projects connecting them to the network. This includes express lanes along US 101, I-880, and SR 237.

3.2.4 Connecting Transportation Centers to Regional Communications Network

Finally, in order to meet Objective 4-2, it is recommended to install new communications infrastructure and connect transportation agencies to the regional communications network. Transportation agencies include transit agencies and traffic management centers. This objective is related to Goal 4 which provides secure and reliable communications for transportation agencies in the region.

There are seven proposed projects that include installing new communications infrastructure from transit agencies to the regional communications network:

- AC Transit at 1600 Franklin St, Oakland, CA 94612
- SFMTA at 1 S Van Ness Ave, San Francisco, CA 94103
- Samtrans/Caltrain at 1250 San Carlos Ave, San Carlos, CA 94070
- BART at Kaiser Center, 300 Lakeside Dr, Oakland, CA 94612
- WestCAT at 601 Walter Ave, Pinole, CA 94564
- LAVTA at 1362 Rutan Court, Suite 100, Livermore, CA 94551
- SolTrans at 311 Sacramento St, Vallejo, CA 94590

There is one proposed project that includes sharing communications infrastructure from a transit agency to the regional communications network :

- VTA at 55-A W Santa Clara St, San Jose, CA 95113

MTC has identified six regionally significant TMCs that should be connected to the regional communications network. Three locations include installing new communications infrastructure from TMCs to the regional communications network:

- Caltrans District 4 Office at 111 Grand Ave, Oakland, CA 94612
- City of San Francisco at 1445 Market Street, San Francisco, CA
- City of Oakland at 1 Frank H Ogawa Plaza, Oakland, CA 94612

Two locations include sharing existing communications infrastructure from TMCs to the regional communications network:

- City of San Jose at 200 E. Santa Clara St. San Jose, CA 95113
- City of Fremont at 39550 Liberty St. Fremont, CA 94538
- City of Dublin at 100 Civic Plaza Dublin, CA 94568

The proposed project list is not exhaustive as it can include any transportation center in the nine-county Bay Area. In the initial stages of the Implementation Plan, we focus on the main agencies that would benefit from connection to the regional communications network. This is intended to be a living document, and direction for how all cities can connect to the regional communications network will be discussed in a later iteration of the Regional Communication Strategic Investment Plan.

3.3 Project Selection Results

Table 2 below presents the proposed projects (in no particular order) and notes which objective they satisfy. The proposed projects are not automatically linked to a form of funding and are subject to change based on stakeholder input, funding constraints, and other priorities. For the purposes of the table, RCN refers to the proposed regional communications network.

Table 2: Proposed Projects and Objectives

ID No.	Project	Obj. 1-1: Regional Communications Backbone	Obj. 1-2: Connect POPs to RCN	Obj. 1-3: Connect Express Lanes to RCN	Obj. 4-2: Connect Transportation Agencies to RCN
1	VTA/Caltrans to dedicate fiber strands installed as part of the planned SR 237 Express Lane project for regional communications purposes	X	-	-	-
2	VTA/Caltrans to dedicate fiber strands installed as part of the planned US 101 Express Lane Project for regional communications purposes	X	-	-	-
3	C/CAG/Caltrans to dedicate fiber strands installed as part of the planned US 101 Managed Lanes Project for regional communications purposes	X	-	-	-
4	Install communications infrastructure along US 101 from Grand Avenue, South San Francisco to I-80	X	-	-	-
5	Install communications infrastructure along I-80 from US 101 to Yerba Buena Island	X	-	-	-
6	Caltrans to make existing conduit infrastructure available for regional communications purposes along I-80 from Yerba Buena Island to Bay Bridge Toll Plaza	X	-	-	-
7	Install communications infrastructure along I-80 and I-880 from the Bay Bridge Toll Plaza to Hegenberger Road	X	-	-	-
8	BAIFA/Caltrans to dedicate existing fiber strands along I-880 from Hegenberger Road to Dixon Landing Road	X	-	-	-
9	Install communications infrastructure along I-880 from Dixon Landing Road to SR 237	X	-	-	-
10	Install communications infrastructure along SR 237 from I-880 to North 1st Street	X	-	-	-

ID No.	Project	Obj. 1-1: Regional Communications Backbone	Obj. 1-2: Connect POPs to RCN	Obj. 1-3: Connect Express Lanes to RCN	Obj. 4-2: Connect Transportation Agencies to RCN
11	Connect Digital Realty data center (Oakland) to nearest regional communications network connection point (I-880, Webster Street interchange)	-	X	-	-
12	Connect Digital Realty data center (San Francisco) to nearest regional communications network connection point (US 101, 3rd Street interchange)	-	X	-	-
13	County of Santa Clara to dedicate existing fiber strands for regional communications purposes to connect Digital Realty data center (San Jose) to nearest regional communications network point (SR 237, Lawrence Expressway interchange)	-	X	-	-
14	City of San Jose to dedicate existing fiber strands for regional communications purposes to connect VTA headquarters (San Jose) to nearest regional communications network point (SR 237, Zanker Road interchange)	-	-	-	X
15	Connect AC Transit headquarters (Oakland) to nearest regional communications network connection point (I-880, Broadway interchange)	-	-	-	X
16	Connect SFMTA headquarters (San Francisco) to nearest regional communications network connection point (US 101/I-80 interchange)	-	-	-	X
17	Connect Samtrans/Caltrain headquarters (San Carlos) to nearest regional communications network connection point (US 101, Holly Street interchange)	-	-	-	X
18	Connect BART headquarters (Oakland) to nearest regional communications network connection point (I-880, Broadway interchange)	-	-	-	X
19	Connect WestCAT headquarters (Pinole) to nearest regional communications network connection point (I-80, Appian Way interchange)	-	-	-	X
20	Connect LAVTA headquarters (Livermore) to nearest regional communications network connection point (I-580, Isabel Avenue interchange)	-	-	-	X
21	Connect SolTrans headquarters (Vallejo) to nearest regional communications network connection point (I-80, Carquinez Bridge)	-	-	-	X

ID No.	Project	Obj. 1-1: Regional Communications Backbone	Obj. 1-2: Connect POPs to RCN	Obj. 1-3: Connect Express Lanes to RCN	Obj. 4-2: Connect Transportation Agencies to RCN
22	City of San Jose to dedicate existing fiber strands for regional communications purposes to connect City of San Jose TMC to nearest regional communications network connection point (SR 237, Zanker Road interchange)	-	-	-	X
23	Connect City of San Francisco TMC to nearest regional communications network connection point (US 101/I-80 interchange)	-	-	-	X
24	City of Fremont to dedicate existing fiber strands for regional communications purposes to connect City of Fremont TMC to nearest regional communications network connection point (I-880, Mowry Avenue interchange)	-	-	-	X
25	Connect City of Oakland TMC to nearest regional communications network connection point (I-880, Broadway interchange)	-	-	-	X
26	Caltrans to dedicate planned fiber strands for regional communications purposes to connect Caltrans D4 office to regional communications network connection (I-80, Bay Bridge Toll Plaza)	-	-	-	X
27	Create redundant loop for the regional communications network across the San Mateo Bridge	X	-	-	-
28	Create redundant loop for the regional communications network across the Dumbarton Bridge	X	-	-	-
29	Install communications infrastructure to connect STA I-80 express lanes to nearest regional communications network connection point (Carquinez Bridge) along I-80 from SR 12 to Carquinez Bridge	-	-	X	X
30	Install communications infrastructure to connect SR 37 managed lanes to nearest regional communications network connection point (I-80) along SR 37 from Railroad Avenue to I-80	-	-	X	-
31	Install communications infrastructure to nearest regional communications network connection point (I-880/SR 238 interchange) along I-580 from I-680 to SR 238 and along SR 238 from I-580 to the I-880	-	-	X	-

ID No.	Project	Obj. 1-1: Regional Communications Backbone	Obj. 1-2: Connect POPs to RCN	Obj. 1-3: Connect Express Lanes to RCN	Obj. 4-2: Connect Transportation Agencies to RCN
32	Install communications infrastructure to connect Sunol express lanes to nearest regional communications network connection point (I-880/SR 262 interchange) along SR 262 from I-680 to I-880	-	-	X	-
33	Install communications infrastructure along the Carquinez Bridge	-	-	X	X
34	Install communications infrastructure along I-80 from the Carquinez bridge to I-580	-	-	X	X
35	City of San Jose to dedicate existing fiber strands for regional communications purposes to connect SR 85 express lanes to nearest regional fiber network connection point (I-880, Zanker Road interchange)	-	-	X	-
36	City of Dublin to dedicate existing fiber strands for regional communications purposes to connect City of Dublin TMC to nearest regional fiber network connection point (I-580, San Ramon Road interchange)	-	-	-	X

4.COMMUNICATIONS TECHNOLOGY EVALUATION

After compiling a list of proposed projects to complete the regional communications network, the project team conducted a communications technology evaluation. The purpose of this technology evaluation was to look at existing and future technologies and determine the most appropriate communications technology for the proposed projects. Technology evaluation was an important component of the development of proposed projects because it evaluated the elements of communications technologies that would help build networks ready for future projects. Additionally, this process became the basis for developing project costs, which will be discussed in more detail in later sections of this document. The technology evaluation was completed using the following process:

- Step 1: Conduct research on the current and future types of communications technologies used by other projects
- Step 2: Develop a list of criteria to evaluate and compare different technologies
- Step 3: Develop a project scoring methodology for each criterion

- Step 4: Evaluate each gap closure project with the developed criteria and scoring methodology to determine most appropriate communications technology for each corridor

This section focuses on providing additional details and information about each of the three steps that were followed to complete the communications technology evaluation.

4.1 Communications Technology Alternatives

The following section provides a summary of all evaluated technology alternatives. For each alternative, the project team provided details about the technology's maintenance, operations, and sample installation cost, ease of scalability, types of equipment supported, life cycle of the technology, data transmission rates, ease of installation, reliability, and physical or environmental constraints. Table 3 states the advantages and disadvantages of each alternative.

4.1.1 Fiber Optics

Fiber Optics (also referred as optical fiber) are cables composed from multiple glass tubes thinner than a human hair and can be installed in underground conduit or overhead wires. While the fiber cabling is relatively inexpensive, the per-mile construction costs for fiber optics tend to be high due to the installation of conduit and networking equipment. Construction costs vary by location, but they can be expected to be greater than $400,000 per mile for a standalone fiber/conduit design and installation project. The maintenance costs of fiber can range around $4,000-$5,600 per mile per year. Installing fiber and conduit may be difficult in environmentally sensitive sites due to the disruptive nature of fiber construction. Fiber can also be installed through aerial cabling, which would lower costs for construction due to the lack of conduit construction and be less intrusive to environmentally sensitive areas. Aerial fiber cabling has lower maintenance costs as well costing around $1,000-$3,000 per mile per year to maintain based on sample costs from the ITS RITA website. Fiber communications networks are highly scalable, they can support virtually all ITS applications and are best suited for corridors with several ITS elements, or corridors where high-bandwidth demand devices such as CCTV cameras or license plate readers are present.

Fiber optics have an assumed life cycle of 25 years, but typically operate past their expected life cycle. Operations and maintenance costs of fiber vary, agencies may choose to update their networking equipment (e.g., edge switches, core switches, transceiver strength) to increase data transmission rates. Typically, network equipment performance specifications are proportionally related to cost. Data transmission rates on agency-owned transportation fiber optic networks can range from 50 Mbps (megabits per second) to 10 Gbps (gigabits per second). Fiber will be critical in transmitting data for wireless 5G networks and connected vehicles.

4.1.2 Low-Bandwidth Wireless Communications

Low-Bandwidth Wireless communications (LBWC) are classified in this document by devices that transmit data in the 900MHz and 2.4 GHz frequencies. LBWC is recommended for communications devices that require low data transmission rates and low transmission latency, such as detectors, traffic signals, and dynamic message signs. The cost of LBWC may range between $2,000-$9,000 per wireless bridge/antenna installation, which may vary significantly by region. Monthly operations and maintenance costs are on the order of $100-400. Installation is easier and less intrusive than fiber because the equipment does not require the installation of conduit or a lengthy physical connection. Drawbacks of LBWC is that they are susceptible to interference from topology, fixed obstructions (trees, buildings, infrastructure), and weather elements (rain, dust, smoke), making them less reliable than a physical hardwire connection.

LBWC can transmit data within a range of 20 miles. Maximum data transmission rates of 50 Mbps can only occur within a range of 10 miles. Generally, LBWC have a life cycle of around 10 years and may be replaced with newer equipment that can support higher data transmission rates and lower latency. Because of LBWCs’ low data transmission rates, it is not recommended for high-bandwidth applications such as video streaming.

4.1.3 High-Bandwidth Wireless Communications

High-Bandwidth Wireless Communications (HBWC) are classified by the 3.65GHz, 4.9GHz, 5.8 GHz, and 60GHz frequencies. HBWC can support CCTV cameras, changeable-message signs, and other high-bandwidth field devices. Because wireless communications operate over air, HBWC are susceptible to interference based on topology, fixed obstructions, and weather. The cost of HBWC may range from $3,000-$10,000 per wireless bridge/antenna installation, and construction/implementation costs can vary widely by region. Installation of HBWC is easier than fiber but requires placing a radio on an existing or new pole within line-of-sight of the receiving equipment. Generally, HBWC has a life cycle of around 10 years. HBWC can transmit data point-to-point or point-to-multipoint within a range of 10 miles. Maximum data transmission rate of 1 Gbps can only occur within a 3-mile range. While the data transmission rate of HBWC is greater than LBWC, data transmission latency may be greater due to high-frequency wave’s greater likelihood of interference from physical and environmental barriers.

4.1.4 Leased Communications

Leased communications can include any type of communications medium (e.g., wireless, fiber, coaxial cable, twisted pair copper) that can be leased for a recurring cost, which is based on selected medium and application. Companies that provide leased line communications include AT&T Business, Comcast Business, Verizon for Business, and various others. In the short term, leased line communications can reduce the initial capital cost of a project as the agency does not have to fund the cost of equipment, construction, and maintenance. However, depending on the duration of the lease arrangement, agencies may spend more on recurring costs than they otherwise would have invested in the development of an agency-owned communications network. Leased communications can be scaled to accommodate all types of typical ITS applications, from low bandwidth to high bandwidth devices, depending on the amount of network capacity available in a given geographic area. Most leased communications pricing structures are set up to charge more for services that provide high-bandwidth data transmission.

It is likely that in the future, private communications providers will require more cell sites in the local agency right-of-way. This may provide an opportunity for agencies to leverage their right-of-way in exchange for favorable agreements with private providers.

***Table 3**: Advantages and Disadvantages of Various Communications Technology Alternatives*

Technology Name	Advantages	Disadvantages	Equipment Supported
Fiber	• Fastest data transmission rates • Reliable connection • Low Maintenance costs • Reduces access points which increases security	• High installation costs	• CCTV cameras • CMS • Vehicle Detectors • Connected vehicles • Center-to-field and peer-to-peer traffic signal system • Vehicle detectors
Low-Bandwidth Wireless Communications	• Provides long distance data transmission (10-20 miles) • Less prone to interference from weather or topology • Lower transmission latency	• Low throughput speeds (≤ 50 Mbps) • Prone to disruption by weather or other wireless users • Requires additional poles and equipment to be installed (if not previously installed) • Cannot accommodate all equipment types	• CMS • Vehicle Detectors • Connected vehicles • Peer-to-peer traffic signal system • Vehicle detectors
High-Bandwidth Wireless Communications	• Higher throughput speeds (≤ 300 Mbps) • Does not require a physical connection between end equipment	• Prone to interference due to weather and/or other wireless signals • Limited to short distances (≤ 10 miles) • Requires additional poles and equipment to be installed (if not previously installed)	• CCTV cameras • CMS • Vehicle Detectors • Connected vehicles • Center-to-field and peer-to-peer traffic signal system • Vehicle detectors

Technology Name	Advantages	Disadvantages	Equipment Supported
Leased Communications	• Low recurring operations and maintenance costs • No or low capital costs	• High recurring leasing costs • Wireless service connection may be unreliable during special events or extreme weather conditions • Wireless service can be affected by large call/data volumes • Expensive to scale because of third party rates	• CCTV cameras • CMS • Vehicle Detectors • Connected vehicles • Center-to-field and peer-to-peer traffic signal system • Vehicle detectors

4.1.5 Future Transportation Technology

This section provides an overview of emerging transportation technology and the equipment that may affect the Bay Area's communications needs in the future.

Connected and Autonomous Vehicles (CV/AV) utilize GPS, radar, dedicated short-range communications (DSRC), or lidar to record a vehicle's geospatial position and relay information to vehicles/infrastructure on the road. The Federal Communications Commission (FCC) dedicated 7 channels within the 5.9 GHz frequency band for DSRC communications. The first of these channels (172) is reserved for vehicle-to-vehicle (V2V) communications and the last channel (184) is reserved for public safety for vehicle-to-infrastructure (V2I) communications.

Connected vehicles can wirelessly communicate to surrounding vehicles through a DSRC on-board unit (OBU) and to infrastructure equipped roadside units (RSUs). OBU's have an expected range of approximately 1 to 300 meters and data transmission rate of up to 6 Mbps. The data transmission rate will be limited to the local environment may be lower than 6 Mbps. and vehicles equipped with DSRC can communicate roadway conditions to the driver/vehicle, manage upstream and downstream traffic, and detect dangerous driving maneuvers. Currently, production vehicles can be equipped with GPS and radar (in the form of adaptive-cruise control), but DSRC is currently in operation in the form of the Signal Phasing and Timing (SPaT).

Expected costs for OBUs can exceed $1,000 and RSUs can exceed $5,000 based on deployments from Georgia Department of Transportation. However, the average cost for a CV deployment in New York City averaged around $3,000 per vehicle (including planning, implementation of OBUs and RSUs, software development, outreach, etc.). Implementing CV technology on a large scale requires a large amount of bandwidth and requires an extensive fiber network for long-haul and short-haul data transmission.

5G is the fifth generation of cellular (wireless) mobile communications, defined by the International Telecommunications Union (ITU) Institute for Market Transformation (IMT)-2020 standard. 5G networks operate in the millimeter wave spectrum, which contains relatively high frequency waves (between 30-300 GHz). 5G networks place multiple small cellular (small cell) towers within 250 meters from each other to reduce coverage gaps. 5G will deliver a more expansive, reliable, and quicker network than 4G and is expected to provide user experienced data rates comparable to residential fiber roughly 100 Mbps (center to field).

There is an existing 5G network deployment being implemented in Sacramento. 5G networks are expected to launch in San Francisco, San Jose, Los Angeles, and San Diego by 2020 by AT&T and Verizon. AT&T has already deployed small-scale test networks in San Francisco and San Jose. It may be assumed that initial pricing for 5G licensing will be relatively more expensive than 4G and decrease as 5G networks expand their coverage.

Ford is developing CV/AV communications technology using 5G networks instead of DSRC. There is not a standard for connected vehicle technology yet as the industry continues to evaluate and pilot 5G and DSRC technologies.

4.1.6 ITS Bandwidth Requirements

Transportation networks require bandwidth for two primary functions: video recording devices (e.g., CCTV cameras and vehicle detection equipment) and traffic data recording devices (e.g., vehicle detection, changeable message signs (CMS), and traffic signals).

Most traffic data devices were derived from a low-bandwidth serial networking environment that has been migrated to Ethernet platforms using terminal server technologies. As a result, traffic devices require relatively low data transmission rates (typically lower than 96 kbps). For the Regional Communications Strategic Investment Plan, the project team assumed data transmission estimates for controller related devices (e.g. CMS, vehicle detection, traffic signals, toll readers, ramp meters) to be around 192 Kbps to account for increase in data usage and device density over time.

Video recording equipment requires higher data transmission rates than traffic data devices. H.265/MPEG-4 video encoding improvements have significantly lowered the data transmission rates for high-definition (HD) and standard definition (SD) recording equipment compared to MPEG-2. HD video and SD video feeds can be provided with data transmission rates of less than 3 Mbps and 1 Mbps, respectively. It should be noted that since vehicle occupancy detection (VOD) and license plate reader (LPR) cameras utilize HD camera equipment and are not in continuous operation, it can be assumed that these systems will require similar data rates to HD CCTV.

Publication FHWA-JPO-17-589 by the Department of Transportation’s (DOT) ITS Joint Program Office’s (JPO) established that dedicated short-range communications RSUs shall transmit radio signals at a rate of 6 Mbps. The full data rate may not be needed.

Table 4 provides planning-level data rate estimates for various ITS components. These bandwidth values were derived from similar ITS projects and applications, and were estimated conservatively to accommodate for future ITS network growth.

***Table 4*:** Planning-Level Estimates for ITS Device Bandwidth

Device	Bandwidth (Per Connection)
Toll Reader	128 Kbps
Traffic Controller	192 Kbps
Vehicle Detectors	1.024 Mbps
SD CCTV Camera	1.28 Mbps
VOD Camera	3.5 Mbps
LPR Camera	3.5 Mbps
HD CCTV Camera	3.5 Mbps
DSRC Radio	6 Mbps

4.2 Communications Technology Evaluation Methodology

Below is an outline of the methodology used to determine the most appropriate communications technology for each project that requires the installation of new communications infrastructure.

4.2.1 Criteria Factors

The following are factors included in the evaluation model used to determine which communications alternative is most appropriate for each project:

- **Device density** – As device density increases, bandwidth demand increases. Devices considered here include: vehicle lane detectors, ramp meters, CCTV cameras (freeway and/or arterial), changeable message signs (freeway and/or arterial), and traffic signals.
- **CCTV Cameras**– Does the route/segment include CCTV cameras? CCTV cameras are considered separately due to the high bandwidth requirements of CCTV cameras relative to other typical ITS devices. A route with active traffic monitoring cameras will demand relatively high bandwidth.
- **Freeway** – Is the route/segment along a freeway? A freeway has more available right-of-way compared to an arterial or non-restricted access facility, which makes it easier to construct new communications infrastructure.
- **Existing ITS Technology Corridor** – Is the route/segment along an existing ITS technology corridor such as express lanes, integrated corridor management (ICM), or Smart corridor? These corridors have a need for high-quality, reliable communications and require high bandwidth capacity for supporting devices. The route/segment has existing infrastructure that can be leveraged.
- **Planned ITS Technology Corridor** – Is the route/segment along a planned ITS technology corridor? These corridors will have a higher need for high-quality, reliable communications and require high bandwidth capacity for supporting devices.
- **Parallel construction project** – Will there be another project under construction in the same area within the next 24 months? This presents an opportunity to incorporate communications network elements that may not otherwise be designed or constructed as standalone projects.

- **Proximity to backbone** – Is the route/segment near an existing fiber backbone? This provides more incentive to tie into, and extend, the existing fiber backbone if it is within a reasonable distance, 2 miles or less.
- **Proximity to BART**– Is the route/segment near a BART access point? This provides more incentive to tie into BART's existing fiber network if it is within a reasonable distance, 2 miles or less.
- **Constructability: Environmentally sensitive area** – Does the route/segment traverse an environmentally sensitive area (ESA)? If so, a less intrusive communications alternative would be preferable for the sake of timely implementation.
- **Constructability: Bridge** – Does the route/segment traverse a bridge? If so, this may impact the preferred communications alternative. Installing new communications infrastructure like fiber conduit on a bridge structure can present significant constructability challenges.

4.2.2 Scoring Matrix of Weighted Values

Each factor was assigned a weighted value from -3 to 3 per communications alternative (see Table 5). The following points outline the strategy used to assign weighted values.

- Positive ranking conveys a relative advantage.
  - 3 – communications option is very beneficial.
  - 2 – communications option is moderately beneficial.
  - 1 – communications option is slightly beneficial.
- Zero indicates neutral impact relative to the other alternatives.
  - 0 – communications option is neutral.
- Negative ranking conveys a relative disadvantage.
  - -1 – communications option is slightly less beneficial.
  - -2 – communications option is moderately less beneficial.
  - -3 – communications option is significantly less beneficial.

The communications alternative's score is the sum of all its weighted values. Table 5 shows the scoring matrix of weighted values for each criteria factor. See Appendix A for a detailed discussion of each weighted value assigned.

Table 5: Scoring Matrix of Weighted Values

	Fiber	Low-Bandwidth Wireless	High-Bandwidth Wireless	Leased Comm
< 1 device per mile	-2	1	-2	2
1-5 devices per mile	-1	0	-1	1
> 5 devices per mile	3	-3	2	0
CCTV Cameras	3	-3	1	1
Freeway	3	1	2	-1
Existing ITS Technology Corridor	3	-2	-1	2
Planned ITS Technology Corridor	3	-3	0	1
Near term construction (less than 24 months)	3	1	1	0
Less than 2 miles from Backbone	3	-3	2	-3
More than 2 miles from Backbone	1	0	2	1
Less than 2 miles from BART	3	-3	2	-3
More than 2 miles from BART	1	0	2	1
Environmentally sensitive area	-2	1	2	2
Bridge crossing	-2	1	2	1

4.2.3 Evaluation Model Results

The communications alternative with the highest score is the most appropriate alternative. The communications alternative with the lowest score is the least appropriate alternative.

4.3 Communications Technology Evaluation Results

Appendix B outlines the scoring matrix of weighted values for each project. The final scoring matrix results are summarized in Table 6 below. Only proposed projects that involve installation of communications infrastructure were evaluated for the most appropriate technology.

Fiber optic cable and high-speed wireless communications were equally rated as an appropriate technology for Projects #30 and #33. Because of the prevalence of fiber communications throughout the rest of the regional communications network, fiber was recommended over wireless.

Table 6: Technology Evaluation Results

ID No.	Project	Most Appropriate Technology
4	Install communications infrastructure along US 101 from Grand Avenue, South San Francisco to I-80	Fiber Communications
5	Install communications infrastructure along I-80 from US 101 to Yerba Buena Island	Fiber Communications
7	Install communications infrastructure along I-80 and I-880 from the Bay Bridge Toll Plaza to Hegenberger Road	Fiber Communications
9	Install communications infrastructure along I-880 from Dixon Landing Road to SR 237	Fiber Communications
10	Install communications infrastructure along SR 237 from I-880 to North 1st Street	Fiber Communications
11	Connect Digital Realty data center (Oakland) to nearest regional communications network connection point (I-880, Webster Street interchange)	Fiber Communications
12	Connect Digital Realty data center (San Francisco) to nearest regional communications network connection point (US 101, 3rd Street interchange)	Fiber Communications
15	Connect AC Transit headquarters (Oakland) to nearest regional communications network connection point (I-880, Broadway interchange)	Fiber Communications
16	Connect SFMTA headquarters (San Francisco) to nearest regional communications network connection point (US 101/I-80 interchange)	Fiber Communications
17	Connect Samtrans/Caltrain headquarters (San Carlos) to nearest regional communications network connection point (US 101, Holly Street interchange)	Fiber Communications
18	Connect BART headquarters (Oakland) to nearest regional communications network connection point (I-880, Broadway interchange)	Fiber Communications
19	Connect WestCAT headquarters (Pinole) to nearest regional communications network connection point (I-80, Appian Way interchange)	Fiber Communications

ID No.	Project	Most Appropriate Technology
20	Connect LAVTA headquarters (Livermore) to nearest regional communications network connection point (I-580, Isabel Avenue interchange)	Fiber Communications
21	Connect SolTrans headquarters (Vallejo) to nearest regional communications network connection point (I-80, Carquinez Bridge)	Fiber Communications
23	Connect City of San Francisco TMC to nearest regional communications network connection point (US 101/I-80 interchange)	Fiber Communications
25	Connect City of Oakland TMC to nearest regional communications network connection point (I-880, Broadway interchange)	Fiber Communications
29	Install communications infrastructure to connect STA I-80 express lanes to nearest regional communications network connection point (Carquinez Bridge) along I-80 from SR 12 to Carquinez Bridge	Fiber Communications
30	Install communications infrastructure to connect SR 37 managed lanes to nearest regional communications network connection point (I-80) along SR 37 from Railroad Avenue to I-80	Fiber Communications
31	Install communications infrastructure to nearest regional communications network connection point (I-880/SR 238 interchange) along I-580 from I-680 to SR 238 and along SR 238 from I-580 to the I-880	Fiber Communications
32	Install communications infrastructure to connect Sunol express lanes to nearest regional communications network connection point (I-880/SR 262 interchange) along SR 262 from I-680 to I-880	Fiber Communications
33	Install communications infrastructure along the Carquinez Bridge	Fiber Communications
34	Install communications infrastructure along I-80 from the Carquinez bridge to I-580	Fiber Communications

Figure 5 shows the proposed full build out of the regional communications network throughout the nine-county Bay Area. It is assumed that “connecting” to the regional communications network requires a physical fiber cable splice.

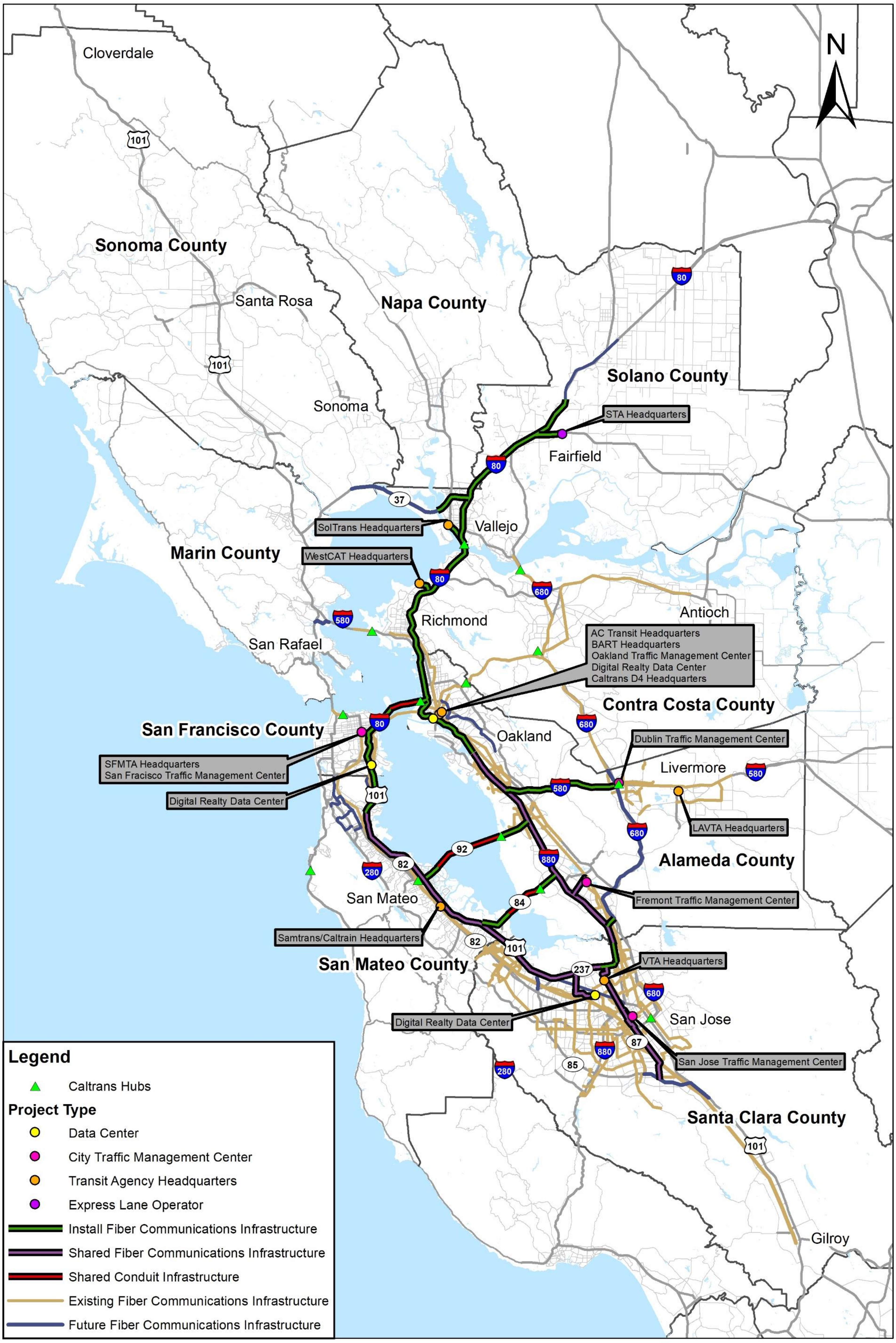

Figure 5: Proposed Regional Fiber Communications Network Build-Out

There is no existing infrastructure dedicated to the regional communications network, therefore it will be made up of the projects proposed in this section. When a project sponsor is deciding whether their project aligns with a project proposed in this Plan, they should use their best judgement to ensure consideration of projects that would meet the goals of the regional communications network. Figure 6 is a decision tree that the governing body of the regional communications network can use to evaluate opportunities to build-out the physical infrastructure. At this stage of the Regional Communication Strategic Investment Plan the governing body has not been identified.

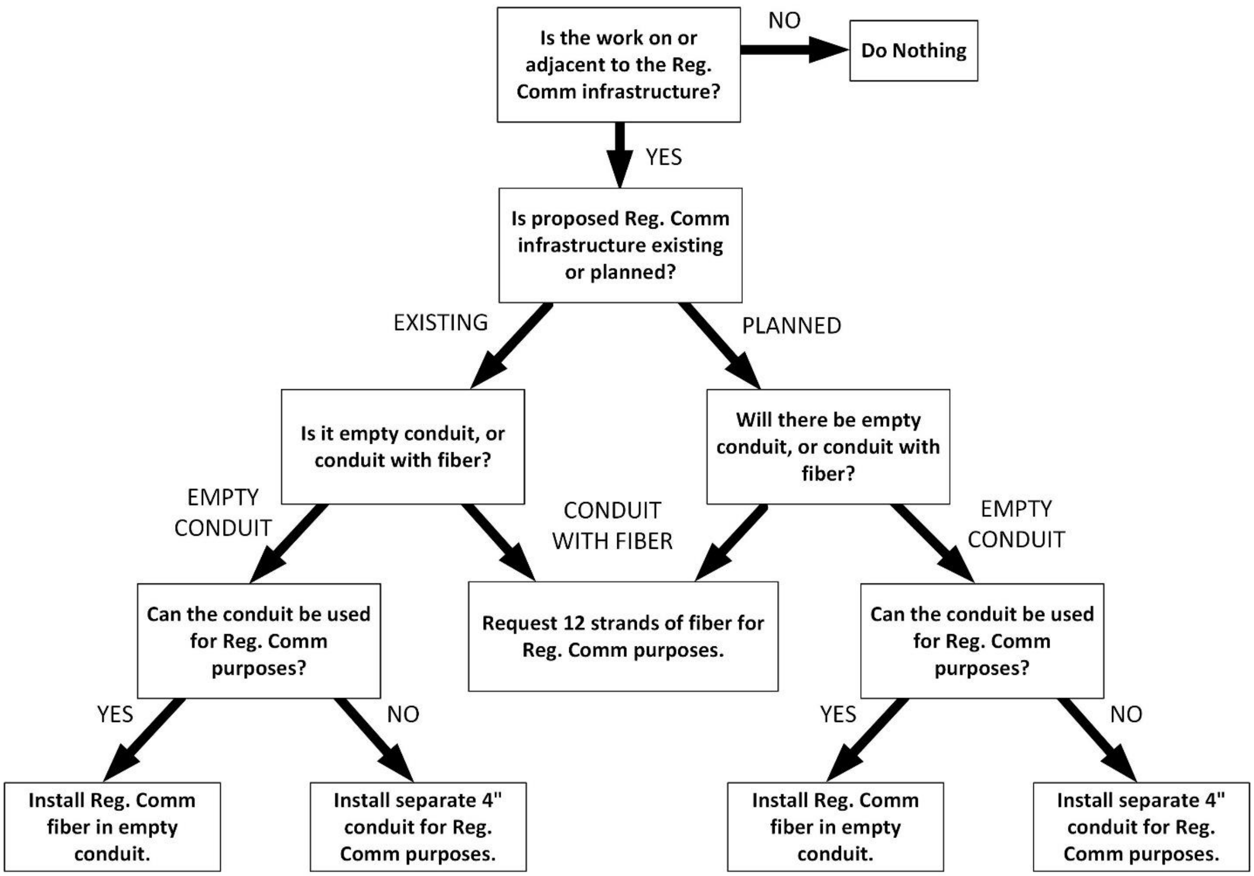

Figure 6: Decision Tree for Integrating Regional Communications during Project Development

5 COST ANALYSIS/FUNDING PLAN OPTIONS

After deriving a proposed list of projects, the project team provided project-level costs, return on investment calculations, and potential funding sources for these projects. The team categorized projects into three main types – sharing conduit and fiber, sharing conduit, and installing conduit and fiber. In this section, detailed explanations for the assumptions made to find the per mile construction and recurring costs of each proposed project type are provided. To justify high capital costs of fiber installation projects, the project team included a discussion on the return on investment of fiber as opposed to leasing communications. The appendix includes supplementary calculations for a more detailed explanation of all numbers and estimates in this section.

Although the proposed project costs assume that excavation will be completed solely for the regional communications network infrastructure installation, there are many opportunities to share costs with other departments, agencies, and private companies. It is crucial to the success of the regional communications network for different agencies and departments to coordinate and leverage their investments. Dig Smart or Dig Once policies provide an opportunity to mainstream fiber infrastructure deployment and could be used to develop and expand the regional communications network. The FCC contends that the cost per mile for fiber deployment increases roughly 42% when it is not jointly deployed. The Utah Department of Transportation estimated a 15.5% per mile cost savings when conduit and fiber were installed during a road project rather than being installed independent of a road project.

5.1 Planning Level Cost Estimates

A planning level cost estimate was developed for projects that require sharing fiber communications infrastructure and ones that require installation of fiber communications infrastructure.

All references to maintenance include both preventative maintenance (routine review and maintenance) and corrective maintenance (diagnosis and repair). These costs are sourced from the Maintenance, Diagnostic, and Repair Services of TOS Devices report prepared by Kimley-Horn as part of MTC's Contractor Oversight project along I-880. This report was chosen because it covers a major corridor discussed in this plan and data is recent as it was collected over 13 months between 2016 and 2017.

5.1.1 Sharing Infrastructure Planning Level Cost Estimates

For the purposes of this planning level cost estimate, the project team assumed that sharing agreements have a typical duration of 25 years. The construction cost of the project included furnishing and installing cabinet equipment necessary to connect new fiber strands. The capital construction cost does not include infrastructure because it was assumed that component will be shared. There are two types of sharing projects – sharing conduit infrastructure and sharing fiber and conduit infrastructure. The difference is when sharing conduit infrastructure, one must consider furnishing and installing fiber in the capital cost.

The project team considered recurring operation, maintenance, and administration costs in the development of project costs. It was assumed that the agency would be responsible for half of the overall operation and maintenance costs of the infrastructure per a typical sharing agreement.

Table 7 below shows the costs related to sharing conduit and fiber infrastructure. See Appendix C for a full breakdown of these figures.

Table 7: Unit Costs for Sharing Conduit and Fiber Infrastructure

CONSTRUCTION COST		Units
Equipment Cost	$39,000	Per Mile Per Sharing Agreement
RECCURRING COSTS		**Units**
Operation & Maintenance	$71,000	Per Mile Per Sharing Agreement (25 years)
Administration	$195,000	Per Sharing Agreement (25 years)

Table 8 below shows the costs related to sharing conduit infrastructure. See Appendix C for a full breakdown of these figures.

Table 8: Unit Costs for Sharing Conduit Infrastructure

CONSTRUCTION COST		Unit
Equipment Cost	$87,000	Per Mile Per Agreement
RECCURRING COSTS		**Unit**
Operation & Maintenance	$71,000	Per Mile Per Agreement (Assume 25-year term)
Administration	$195,000	Per Agreement (Assume 25-year term)

Note that the annual recurring costs have been multiplied by 25 years to get the total cost per the duration of the entire sharing agreement.

The project team made some key assumptions in these costs:

- Preliminary engineering costs are 30% of capital equipment construction costs for all projects except for projects crossing a major regional bridge
- Preliminary engineering costs are 50% of capital equipment construction costs for projects crossing a major regional bridge
- No right-of-way, hub equipment, traffic control, miscellaneous construction costs are considered for sharing projects because the infrastructure is already installed.
- System integration costs are 2% of capital equipment construction costs for all projects which are installing new fiber strands into existing conduit infrastructure.

5.1.2 Installing Infrastructure Planning Level Cost Estimates

Construction costs include furnishing and installing fiber, conduit infrastructure, and all relevant equipment (cabinets, splice vaults, etc.). Operation and maintenance make up the annual recurring costs.

For cost estimating purposes, the project team is assuming any project that proposes fiber communications infrastructure along local streets is installing 1-4” conduit. To align with Caltrans’ vision of having four communications conduits along their right-of-way, any project that proposes fiber communications infrastructure along a freeway assumes installation of 4-4” conduit.

To account for the fact that the unit cost of conduit decreases as the project length increases, the project team differentiated between projects that are greater or less than 10 miles. Communications infrastructure on bridges needs to be strapped to the structure which is relatively expensive to install, operate, and maintain.

Table 9 shows the costs related to installing fiber and conduit communications infrastructure. See Appendix C for a full breakdown of these figures.

Table 9: Unit Costs for Installing Fiber and Conduit Infrastructure

CONSTRUCTION COST		Unit
Equipment Cost (1-4” conduit, > 10 miles)	$410,000	Per Mile per Project
Equipment Cost (1-4” conduit, ≤ 10 miles)	$500,000	Per Mile per Project
Equipment Cost (4-4” conduit, > 10 miles)	$440,000	Per Mile per Project
Equipment Cost (4-4” conduit, ≤ 10 miles)	$530,000	Per Mile per Project
Equipment Cost (1-4” conduit, Regional Bridge)	$590,000	Per Mile per Project
RECCURRING COSTS		**Unit**
Operation & Maintenance	$141,000	Per Mile Per Project (25 years)
Operation & Maintenance (Regional Bridge)	$210,000	Per Mile Per Project (25 years)

To compare the costs of installing and sharing infrastructure, the annual recurring costs associated with installing infrastructure has been multiplied by 25 years to get the total cost per the duration of a typical sharing agreement.

Additional key assumptions in the costs listed as part of Table 9 include:

- Lateral connections to TMS equipment are not included
- Preliminary engineering costs are 30% of capital equipment construction costs.
- Preliminary engineering costs are 50% of capital equipment construction costs for projects crossing a major regional bridge.
- Right-of-way costs for projects on the freeway are assumed to be 0.5% of capital equipment construction costs.
- Right-of-way costs for projects connecting a transit center, data center, or TMC to the regional communications network have been assumed to be 1% of construction because they require construction along local streets.
- Hub equipment costs are $15,000/mile for all projects along the fiber backbone.
- Traffic control costs are 50% of capital equipment construction costs.
- Miscellaneous construction costs (such as lane closure and water control) are 20% of capital equipment construction costs.
- System integration costs are 2% of capital equipment construction costs.

5.1.3 Project Planning Level Cost Estimates

Table 10 below shows the costs of all proposed projects. See Appendix D for example calculations for all the different types of projects.

Table 10: Planning-Level Project Cost Estimates

ID No.	Project	Recommended Technology	Project Length (miles)	PE Cost	R/W Cost	Hub Equipment Cost Per Mile	Traffic Control Cost	Miscellaneous Construction Costs	Systems Integration	Construction Cost (Furnish/Install)	Recurring Cost (Summed Over 25 Years)	Total Cost (Over 25 Years)
1	VTA/Caltrans to dedicate fiber strands installed as part of the planned SR 237 Express Lane project for regional communications purposes	N/A	2	$ 12,000	N/A	N/A	N/A	N/A	N/A	$ 79,000	$ 336,000	$ 427,000
2	VTA/Caltrans to dedicate fiber strands installed as part of the planned US 101 Express Lane Project for regional communications purposes	N/A	11	$ 65,000	N/A	N/A	N/A	N/A	N/A	$ 433,000	$ 971,000	$ 1,469,000
3	C/CAG/Caltrans to dedicate fiber strands installed as part of the planned US 101 Managed Lanes Project for regional communications purposes	N/A	23	$ 136,000	N/A	N/A	N/A	N/A	N/A	$ 906,000	$ 1,817,000	$ 2,859,000
4	Install communications infrastructure along US 101 from Grand Avenue, South San Francisco to I-80	Fiber Communications	8	$ 1,273,000	$ 21,000	$ 120,000	$ 2,122,000	$ 849,000	$ 85,000	$ 4,243,000	$ 1,128,000	$ 9,841,000
5	Install communications infrastructure along I-80 from US 101 to Yerba Buena Island	Fiber Communications	4	$ 1,181,000	$ 12,000	$ 60,000	$ 1,181,000	$ 472,000	$ 47,000	$ 2,362,000	$ 840,000	$ 6,155,000
6	Caltrans to make existing conduit infrastructure available for regional communications purposes along I-80 from Yerba Buena Island to Bay Bridge Toll Plaza	N/A	4	$ 175,000	N/A	N/A	N/A	N/A	$ 7,000	$ 350,000	$ 477,000	$ 1,009,000
7	Install communications infrastructure along I-80 and I-880 from the Bay Bridge Toll Plaza to Hegenberger Road	Fiber Communications	10	$ 1,591,000	$ 27,000	$ 150,000	$ 2,652,000	$ 1,061,000	$ 106,000	$ 5,304,000	$ 1,410,000	$ 12,301,000
8	BAIFA/Caltrans to dedicate existing fiber strands along I-880 from Hegenberger Road to Dixon Landing Road	N/A	26	$ 154,000	N/A	N/A	N/A	N/A	N/A	$ 1,024,000	$ 2,028,000	$ 3,206,000
9	Install communications infrastructure along I-880 from Dixon Landing Road to SR 237	Fiber Communications	2	$ 318,000	$ 5,000	$ 30,000	$ 531,000	$ 212,000	$ 21,000	$ 1,061,000	$ 282,000	$ 2,460,000
10	Install communications infrastructure along SR 237 from I-880 to North 1st Street	Fiber Communications	2	$ 318,000	$ 5,000	$ 30,000	$ 531,000	$ 212,000	$ 21,000	$ 1,061,000	$ 282,000	$ 2,460,000
11	Connect Digital Realty data center (Oakland) to nearest regional communications network connection point (I-880, Webster Street interchange)	Fiber Communications	0.6	$ 90,000	$ 3,000	N/A	$ 150,000	$ 60,000	$ 6,000	$ 300,000	$ 85,000	$ 694,000
12	Connect Digital Realty data center (San Francisco) to nearest regional communications network connection point (US 101, 3rd Street interchange)	Fiber Communications	0.6	$ 90,000	$ 3,000	N/A	$ 150,000	$ 60,000	$ 6,000	$ 300,000	$ 85,000	$ 694,000

ID No.	Project	Recommended Technology	Project Length (miles)	PE Cost	R/W Cost	Hub Equipment Cost Per Mile	Traffic Control Cost	Miscellaneous Construction Costs	Systems Integration	Construction Cost (Furnish/Install)	Recurring Cost (Summed Over 25 Years)	Total Cost (Over 25 Years)
13	County of Santa Clara to dedicate existing fiber strands for regional communications purposes to connect Digital Realty data center (San Jose) to nearest regional communications network point (SR 237, Lawrence Expressway interchange)	N/A	4	$ 24,000	N/A	N/A	N/A	N/A	N/A	$ 158,000	$ 477,000	$ 659,000
14	City of San Jose to dedicate existing fiber strands for regional communications purposes to connect VTA headquarters (San Jose) to nearest regional communications network point (SR 237, Zanker Road interchange)	N/A	7	$ 41,000	N/A	N/A	N/A	N/A	N/A	$ 276,000	$ 689,000	$ 1,006,000
15	Connect AC Transit headquarters (Oakland) to nearest regional communications network connection point (I-880, Broadway interchange)	Fiber Communications	0.7	$ 105,000	$ 4,000	N/A	$ 175,000	$ 70,000	$ 7,000	$ 350,000	$ 99,000	$ 810,000
16	Connect SFMTA headquarters (San Francisco) to nearest regional communications network connection point (US 101/I-80 interchange)	Fiber Communications	1	$ 150,000	$ 5,000	N/A	$ 250,000	$ 100,000	$ 10,000	$ 500,000	$ 141,000	$ 1,156,000
17	Connect Samtrans/Caltrain headquarters (San Carlos) to nearest regional communications network connection point (US 101, Holly Street interchange)	Fiber Communications	0.8	$ 120,000	$ 4,000	N/A	$ 200,000	$ 80,000	$ 8,000	$ 400,000	$ 113,000	$ 925,000
18	Connect BART headquarters (Oakland) to nearest regional communications network connection point (I-880, Broadway interchange)	Fiber Communications	1	$ 150,000	$ 5,000	N/A	$ 250,000	$ 100,000	$ 10,000	$ 500,000	$ 141,000	$ 1,156,000
19	Connect WestCAT headquarters (Pinole) to nearest regional communications network connection point (I-80, Appian Way interchange)	Fiber Communications	2	$ 300,000	$ 10,000	N/A	$ 501,000	$ 200,000	$ 20,000	$ 1,001,000	$ 282,000	$ 2,314,000
20	Connect LAVTA headquarters (Livermore) to nearest regional communications network connection point (I-580, Isabel Avenue interchange)	Fiber Communications	0.9	$ 135,000	$ 5,000	N/A	$ 225,000	$ 90,000	$ 9,000	$ 450,000	$ 127,000	$ 1,041,000
21	Connect SolTrans headquarters (Vallejo) to nearest regional communications network connection point (I-80, Carquinez Bridge)	Fiber Communications	3	$ 450,000	$ 15,000	N/A	$ 751,000	$ 300,000	$ 30,000	$ 1,501,000	$ 423,000	$ 3,470,000
22	City of San Jose to dedicate existing fiber strands for regional communications purposes to connect City of San Jose TMC to nearest regional communications network connection point (SR 237, Zanker Road interchange)	N/A	7	$ 41,000	N/A	N/A	N/A	N/A	N/A	$ 276,000	$ 689,000	$ 1,006,000
23	Connect City of San Francisco TMC to nearest regional communications network connection point (US 101/I-80 interchange)	Fiber Communications	1	$ 150,000	$ 5,000	N/A	$ 250,000	$ 100,000	$ 10,000	$ 500,000	$ 141,000	$ 1,156,000

ID No.	Project	Recommended Technology	Project Length (miles)	PE Cost	R/W Cost	Hub Equipment Cost Per Mile	Traffic Control Cost	Miscellaneous Construction Costs	Systems Integration	Construction Cost (Furnish/Install)	Recurring Cost (Summed Over 25 Years)	Total Cost (Over 25 Years)
24	City of Fremont to dedicate existing fiber strands for regional communications purposes to connect City of Fremont TMC to nearest regional communications network connection point (I-880, Mowry Avenue interchange)	N/A	2	$ 12,000	N/A	N/A	N/A	N/A	N/A	$ 79,000	$ 336,000	$ 427,000
25	Connect City of Oakland TMC to nearest regional communications network connection point (I-880, Broadway interchange)	Fiber Communications	0.6	$ 90,000	$ 3,000	N/A	$ 150,000	$ 60,000	$ 6,000	$ 300,000	$ 85,000	$ 694,000
26	Caltrans to dedicate planned fiber strands for regional communications purposes to connect Caltrans D4 office to regional communications network connection (I-80, Bay Bridge Toll Plaza)	N/A	4	$ 24,000	N/A	N/A	N/A	N/A	N/A	$ 158,000	$ 477,000	$ 659,000
27	Create redundant loop for the regional communications network across the San Mateo Bridge	Fiber Communications	11	$ 1,367,000	$ 11,000	N/A	$ 1,061,000	$ 424,000	$ 54,000	$ 2,734,000	$ 1,253,000	$ 6,904,000
28	Create redundant loop for the regional communications network across the Dumbarton Bridge	Fiber Communications	8	$ 793,000	$ 5,000	N/A	$ 531,000	$ 212,000	$ 31,000	$ 1,585,000	$ 900,000	$ 4,057,000
29	Install communications infrastructure to connect STA I-80 express lanes to nearest regional communications network connection point (Carquinez Bridge) along I-80 from SR 12 to Carquinez Bridge	Fiber Communications	15	$ 476,000	$ 8,000	N/A	$ 793,000	$ 317,000	$ 132,000	$ 1,585,000	$ 2,115,000	$ 15,492,000
30	Install communications infrastructure to connect SR 37 managed lanes to nearest regional communications network connection point (I-80) along SR 37 from Railroad Avenue to I-80	Fiber Communications	5	$ 796,000	$ 13,000	N/A	$ 1,326,000	$ 530,000	$ 53,000	$ 2,652,000	$ 705,000	$ 6,075,000
31	Install communications infrastructure to nearest regional communications network connection point (I-880/SR 238 interchange) along I-580 from I-680 to SR 238 and along SR 238 from I-580 to the I-880	Fiber Communications	12	$ 1,586,000	$ 26,000	N/A	$ 2,643,000	$ 1,057,000	$ 106,000	$ 5,285,000	$ 1,692,000	$ 12,395,000
32	Install communications infrastructure to connect Sunol express lanes to nearest regional communications network connection point (I-880/SR 262 interchange) along SR 262 from I-680 to I-880	Fiber Communications	1	$ 159,000	$ 3,000	N/A	$ 265,000	$ 106,000	$ 11,000	$ 530,000	$ 141,000	$ 1,215,000
33	Install communications infrastructure along the Carquinez Bridge	Fiber Communications	2	$ 531,000	$ 5,000	N/A	$ 531,000	$ 212,000	$ 21,000	$ 1,061,000	$ 420,000	$ 2,781,000
34	Install communications infrastructure along I-80 from the Carquinez bridge to I-580	Fiber Communications	18	$ 2,378,000	$ 40,000	N/A	$ 3,964,000	$ 1,585,000	$ 159,000	$ 7,927,000	$ 2,538,000	$ 18,591,000

ID No.	Project	Recommended Technology	Project Length (miles)	PE Cost	R/W Cost	Hub Equipment Cost Per Mile	Traffic Control Cost	Miscellaneous Construction Costs	Systems Integration	Construction Cost (Furnish/Install)	Recurring Cost (Summed Over 25 Years)	Total Cost (Over 25 Years)
35	City of San Jose to dedicate existing fiber strands for regional communications purposes to connect SR 85 express lanes to nearest regional fiber network connection point (I-880, Zanker Road interchange)	N/A	14	$ 83,000	N/A	N/A	N/A	N/A	N/A	$ 552,000	$ 1,182,000	$ 1,817,000
36	City of Dublin to dedicate existing fiber strands for regional communications purposes to connect City of Dublin TMC to nearest regional fiber network connection point (I-580, San Ramon Road interchange)	N/A	2	$ 12,000	N/A	N/A	N/A	N/A	N/A	$ 79,000	$ 336,000	$ 427,000
											Total Cost	**$ 129,808,000**

5.1.4 Return on Investment

Currently, many agencies are choosing to lease communications from private companies instead of installing their own fiber communications network. This is due to the large capital investment necessary to install conduit infrastructure. Looking at future growth and technology trends – data capacity needs will increase as more devices are added to corridors to improve congestion and safety. As data capacity needs increase, the annual cost of leasing communications increases and installing fiber could potentially become a cost-effective alternative. This is true even though there are currently downward trends in leased line costs per device. This section is meant to outline a return on investment calculation proving that fiber communications can meet future data needs in a cost-efficient manner.

This return on investment calculation will compare leased wireless and fiber communications alternatives in an existing and future scenario along a typical 1-mile urban corridor. See Appendix E for a full list of assumptions used to make these calculations.

The return on investment is based on what is currently commercially available. There are promising technologies, such as 5G, on the near horizon that could give us a reasonable alternative to fiber that could possibly be significantly cheaper or comparable in cost.

5.1.4.1 Existing Conditions

Figure 7 illustrates a typical 1-mile corridor within an urban area with existing devices using leased wireless communications.

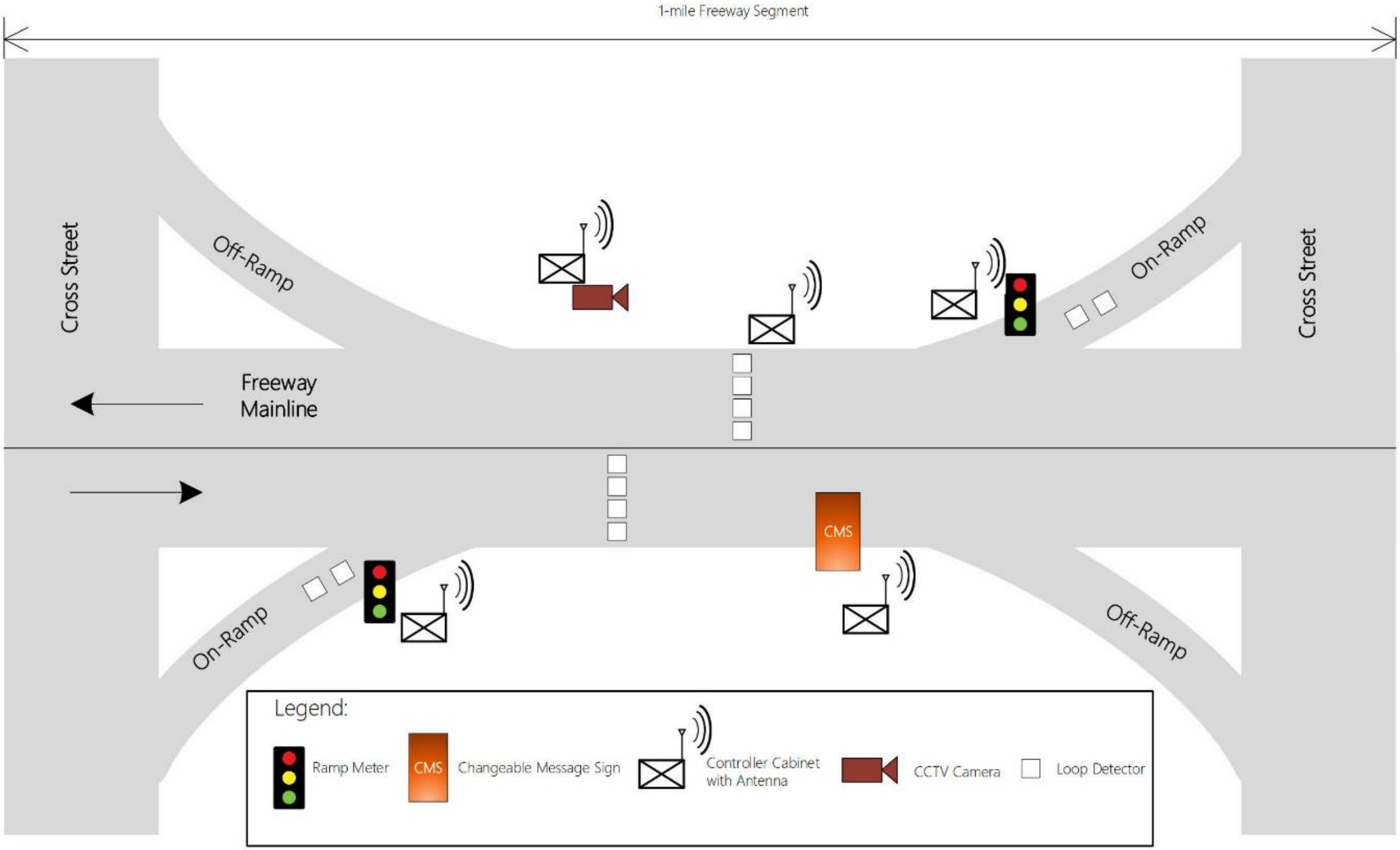

Figure 7: Existing Devices with Wireless Communications

Figure 8 illustrates a typical 1-mile corridor within an urban area with existing devices using fiber communications.

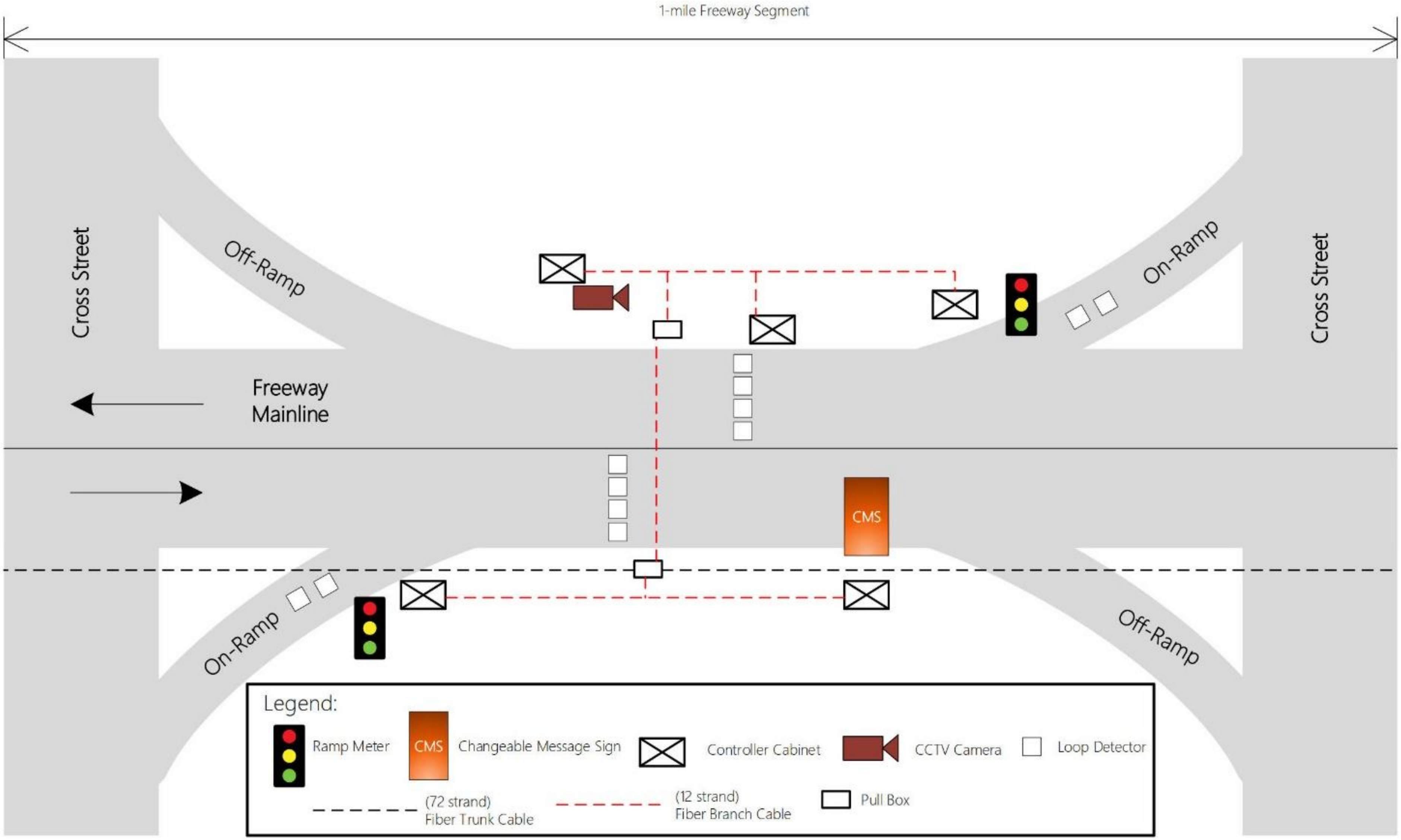

Figure 8: Existing Devices with Fiber Communications

Considering monthly maintenance costs (corrective and preventative), monthly recurring costs, capital costs, and equipment replacement costs it would take 30 years for leasing wireless to break even with fiber communications.

5.1.3.2 Future Conditions

Figure 9 illustrates a typical 1-mile corridor within an urban area with future ITS infrastructure communicating with leased wireless communications. Future ITS infrastructure includes express lane devices, DSRC radios for CV/AV, and HOV enforcement devices.

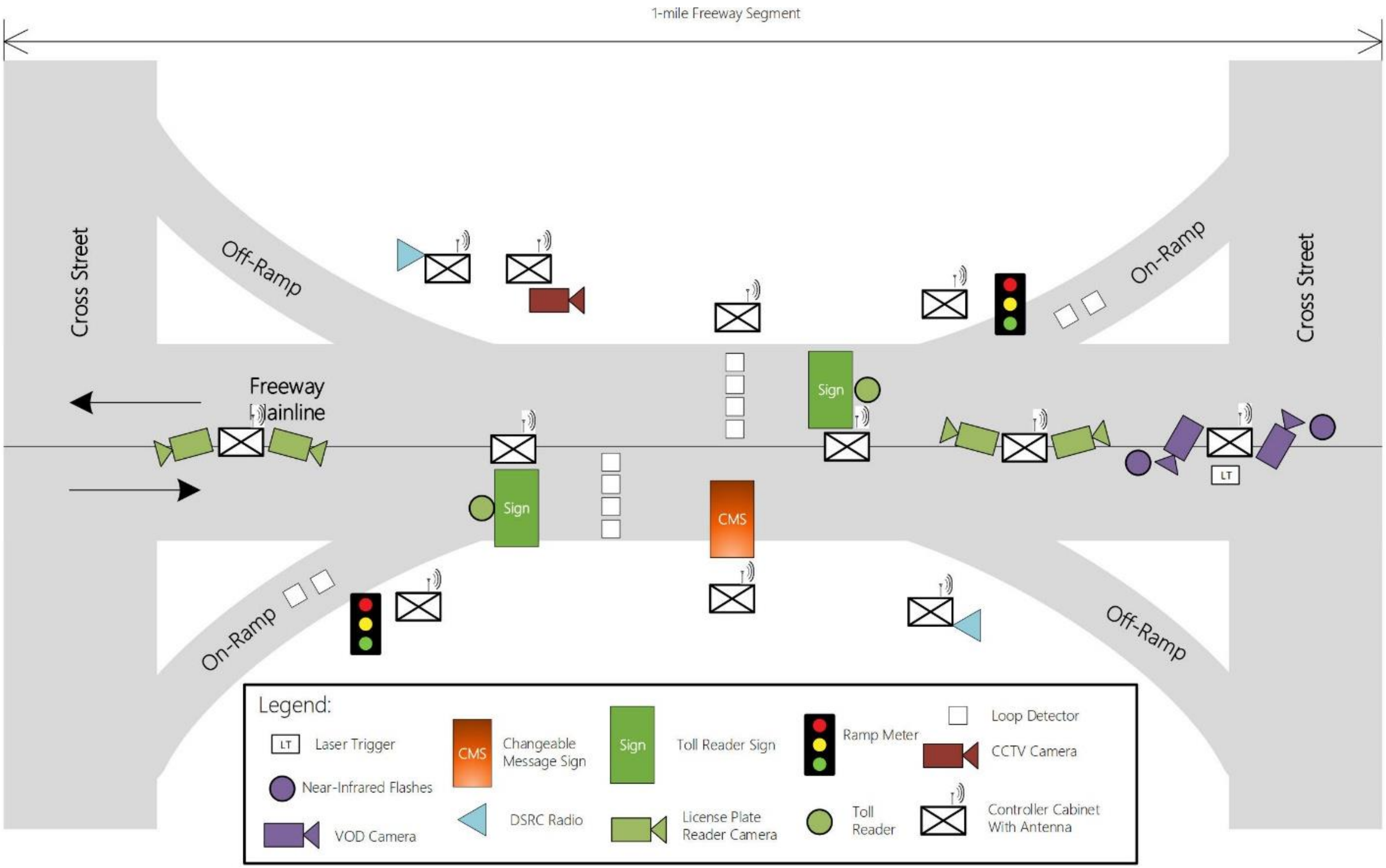

Figure 9: Future Infrastructure with Wireless Communications

Figure 10 illustrates a typical 1 mile corridor within an urban area with future ITS infrastructure communicating with fiber communications. Future ITS infrastructure includes express lane devices, DSRC radios for CV/AV, and HOV enforcement devices.

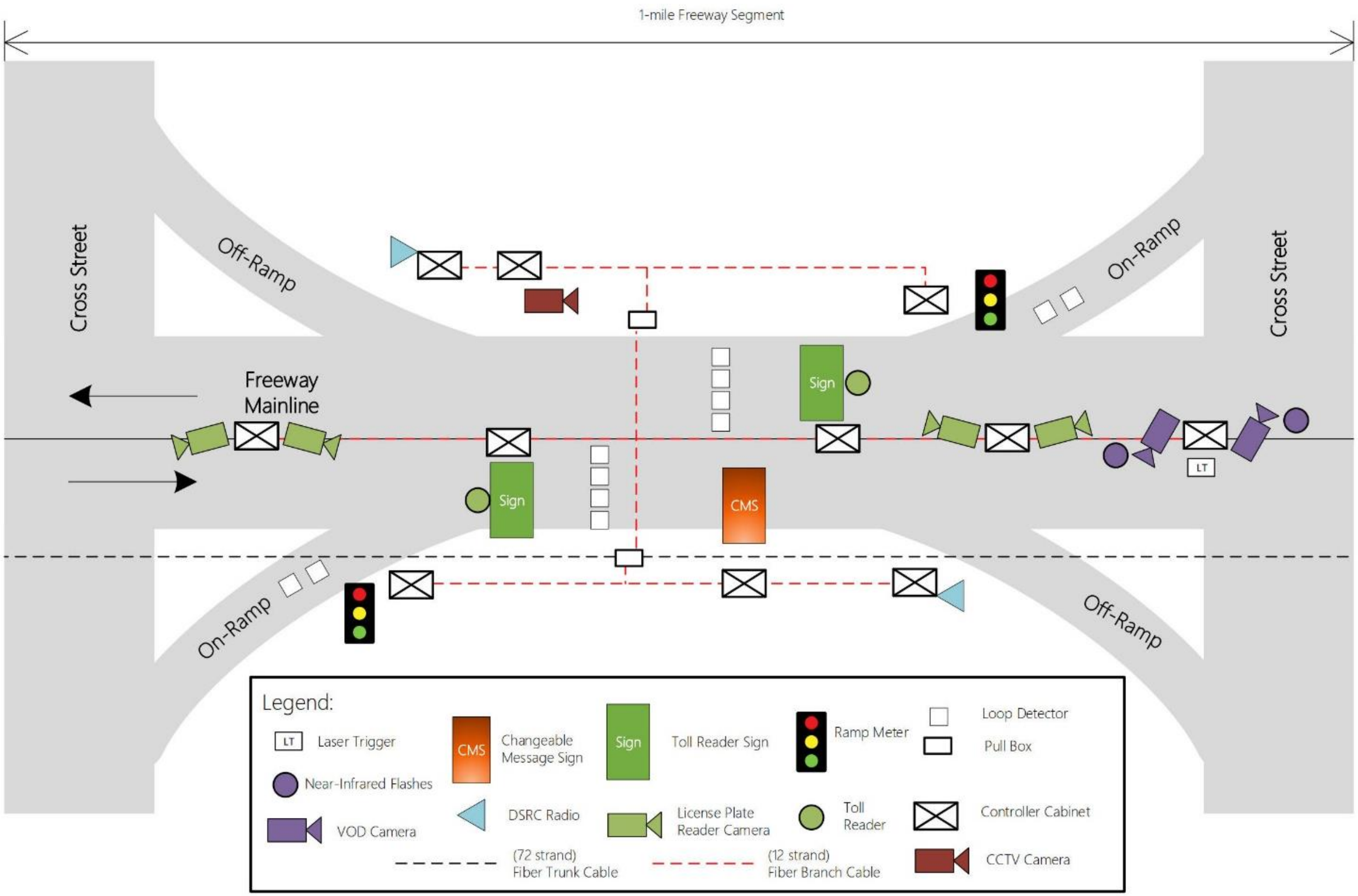

Figure 10: Future Infrastructure with Fiber Communication

Considering monthly maintenance costs (corrective and preventative), monthly recurring costs, capital costs, and equipment replacement costs it would take 15 years for leasing wireless to break even with fiber communications.

5.1.4.2 Return on Investment

The return on investment drops from 30 years to 15 years when comparing an existing scenario to a future scenario of installing fiber communications or leasing wireless communications. This demonstrates that as data capacity needs increase, it is cost effective to install agency-owned fiber communications. The calculation is summarized in Table 11.

Table 11: Return on Investment for Installing Fiber Compared to Leasing Communications

Scenario	Number of Years
Existing Conditions	30
Future Conditions	15

5.2 Project Funding Sources

The following section identifies potential funding sources for projects proposed in the Regional Strategic Investment Plan. Funding types identified for the proposed projects include public funding and unique public-private partnerships (P3s). Each funding sources presented with specific information as it relates to how it may apply to proposed projects.

5.2.1 Public Funding Sources

This section provides an overview of potential public funding sources for proposed projects from local, regional, state, and federal funding programs. Public funding provides multiple programs to assist funding for transportation projects across the country. Additionally, other public funding sources related to economic development benefits and other non-traditional funding programs can be applicable to communications-type projects. Tables 12-14 list the types of projects that can be funded by these programs along with additional program information.

5.2.1.1 Local Funding Programs

With voter approval, Counties may use a variety of local revenue streams to fund fiber communications infrastructure projects. These potential local funding sources include, but are not limited to, sales taxes, property taxes, and public transit fares.

2016 Measure B: In Santa Clara County, voters approved a 30-year, half-cent, countywide sales tax for improvement of transit, highways, expressways, and active transportation. Transportation projects eligible for funds include a new regional rail corridor, expressways, and congestion relief, all of which may potentially include the installation of fiber communications infrastructure. These funds can also be used for road repair and improvements. Excavation completed as part of these projects can be leveraged for the installation of underground fiber communications infrastructure.

5.2.1.2 Regional Funding Programs

Regional funding programs obtain funding from local fees and taxes from programs such as vehicle registration and toll revenues. Regional funds may also come from state and federal programs which directly delegate funds to metropolitan planning organizations (MPOs) which can distribute the appropriate funding to regional congestion management agencies (CMAs). Several regional funding sources are described below.

Regional Measure 3 (RM3): This ballot measure increases Bay Area bridge tolls by $1 starting January 1, 2019 and approves the use of regional bridge toll revenue to finance highway and transit improvements to relieve congestion. While RM3 projects are not solely focused on communications, many of them such as BART to San Jose Phase 2, are likely to include the installation of fiber communications. Highway and transit improvements listed within the RM3 expenditure plan may include the installation of new regional communications, but they are likely to be bundled with congestion relief programs which abide by the goals established in RM3.

Bay Area Urban Areas Security Initiative (UASI): This funding program enhances regional terrorism preparedness in major metropolitan areas through the development of integrated systems for terrorism prevention, protection, response, and recovery. While not directly focused on funding communications projects, UASI program funds communications projects like the Bay Area Regional Interoperable Communications System (BayRICS) Joint Powers Authority BayLoop broadband digital microwave network, which is used to enhance interoperability and connectivity in the region and facilitate traffic within the Bay Area. Funds for fiscal year 2019 will provide financial assistance for planning, organizing, obtaining equipment and training for future terrorist threats, which may include improvements to regional communications.

Lifeline Transportation Program (LTP): This program focuses on projects that improve mobility and accessibility in low-income communities. These communities must be in the one of the Bay Area's nine counties. This program may fund improvements to transit lines which may include fiber installation on routes or station stops. Eligible recipients are transit operators, consolidated transportation service agencies, and cities and counties. There is no precedent for it being a direct funding sources for just a fiber communications installation project, but it may fund improvements to transit lines which could potentially include fiber communications infrastructure.

Regional challenge grants are also a potential funding source for regional communications network projects. Challenge grants require local agencies to prove their buy-in before funds are released. A typical buy-in requirement involves matching a certain percentage of the project cost. Below is a successful example of a local challenge grant. Similar challenge grants may be administered in the future and be used a potential funding source for projects proposed in this Plan.

Innovative Deployment to Enhance Arterials (IDEA) Challenge Grant: This program is administered by MTC and provides funding for local agencies to deploy advanced technologies along their arterials. The grant awards range from $0.25-3 million with a minimum local cash match of 15% and a minimum in-kind match of 10%. To receive these funds, local agencies must apply for the grant, be evaluated by a panel, and be approved by an MTC commission.

Table 12: Regional Funding Programs

Program	Important Dates	Projects Funded	Max Funds/ Match Limit	Additional Info	Applicable Projects (Table 2)
Regional Measure 3 (RM3)	Toll increase begins January 1, 2019	• BART System Improvements • Caltrain Extension • MUNI Facility Improvements • Express Lanes	• $4.45 billion in highway and transit improvements	• List of RM3 Projects • RM3 Infographic	1, 2, 29, 31, 32
Bay Area Urban Areas Security Initiative (UASI)	Deadline period during Mid-September through Mid-October Follows an annual programming cycle	• Public Information and Warning • Information Sharing • Cybersecurity • Interoperable Communications	• Up to $30 million of funding for fiscal year 2018 • Can fund up to 100% of the project cost	• Bay Area UASI Proposal Guide	4,5,7,9-28, 33, 34, 36
Lifeline Transportation Program (LTP)	Cycle 5 projects approved on July 2018 Follows a two-year programming cycle	• Transit stop improvements • Transportation services for seniors and children	• Provides up to 80% of the funds • Auto-related projects require a 50% match	• CTC Application • CCTA Application • SFCTA Application • VTA Application	5,6,27,28, 33

5.2.1.3 State Funding Programs

The State Highway Account (SHA) is an account that funds a variety of California programs for transportation and traveler mobility purposes. The SHA receives its funds from the State Base Excise Tax and the Federal Highway Trust Fund.

Senate Bill 1 (SB-1): SB-1 is the Road Repair and Accountability Act of 2017, which approved a legislative package that invests $54 billion over the next decade to fix roads, freeways, and bridges across California, while also addressing safety, congestion, accessibility, economic development, air-quality and land use issues. The California Transportation Commission (CTC) administers the funds and evaluates funding allocation. Caltrans will receive roughly half of the allotted SB-1 funds ($26 billion in the next decade) for state-maintained transportation projects and programs which include: Local Street and Road Maintenance and Rehabilitation, Transit Operations and Capital, Local Partnership Program, Active Transportation Program, State Transportation Improvement Program – Regional Share, and Local Planning Grants. The other half of SB-1 funds will be appropriated directly to local roads and transit agencies. Many of the projects that are funded through SB-1 programs may contain communications infrastructure, such as the express lanes, SMART corridor, AC Transit BRT and BART station expansion.

SB-1 funds are distributed through programs such as the State Highway Operation and Protection Program (SHOPP), the Trade Corridor Enhancement Program (TCEP), and the Solutions for Congested Corridors Program (SCCP). SHOPP is currently focused on asset management and addressing system deficiencies.

California Public Utilities Commission California Advanced Services Fund (CASF): The CASF is the Broadband Adoption Account created via Assembly Bill 1665. It provides grants to assist in the building and/or upgrading of broadband infrastructure in areas that are unserved by existing broadband providers. This funding source may be used on the projects proposed as part of this plan if it is able to emphasize its direct benefit to the community. Projects under this funding source are evaluated by their ability to leverage existing regional assets and support the implementation of economic development strategies that advance new ideas. Ranges of awards vary based on CPUC assessment. This funding source is directly related to the expansion of communications assets on a local or regional level. One of the key focus points of this funding source is “digital inclusion,” which seeks to increase publicly available or after-school broadband access in different communities.

California State Transportation Improvement Program (STIP): The California STIP is a multi-year capital improvement program of transportation projects on and off the State Highway System. It is funded through the Transportation Investment Fund as well as other funding sources. STIP programming typically occurs every two years and requires that local agencies seeking funding work with their regional Metropolitan Planning Organization (MPO) to get their projects programmed in the Regional Transportation Improvement Plans (RTIPs). Projects funded through the STIP are evaluated on how the project aligns with furthering regional objectives, particularly for Sustainable Communities Strategies. Like other funding sources mentioned above, the types of projects that can be funded through the STIP creates an opportunity for communications elements to be included as part of other improvements. Some STIP/RTIP projects that include communications improvements are the US 101 managed lanes project, the express lanes projects, and light rail improvements. The challenge with this funding program the planning process that projects must undergo to be programmed into the RTIPs before being considered for STIP funding.

California Transportation Commission Active Transportation Program (CTC ATP): The Active Transportation Program (ATP) was created by Senate Bill 99 and Assembly Bill 101 to encourage increased use of active modes of transportation, such as biking and walking. This program is funded through the federal Transportation Alternative Program, federal Highway Safety Improvement Program (HSIP), and State Highway Account funds. ATP funds are distributed such that 40% of all funds go to MPOs in urban areas with populations greater than 200,000. Projects funded through this source are selected through a competitive program and must meet one or more ATP goals. Projects proposed under the Regional Communications Strategic Investment Plan would need to show how they meet program goals to be considered for this type of funding. Like many of the other funding sources, the challenge with this funding source is bundling projects strategically so that they include a component that allows for upgrading existing communications infrastructure. Potential projects that may include communications infrastructure elements are bike/pedestrian improvements for intersections that require the installation of ITS components.

Table 13: State Funding Programs

Program	Important Dates	Projects Funded	Max Funds/ Match Limits	Additional Info	Applicable Projects (Table 2)
Senate Bill 1 (SB-1)	Varies per program	• Managed lanes • Express lanes • AC Transit BRT Expansion • BART Station Expansion	• SCCP: $250 million in SB1 funds; no match requirement • TCEP: $300 million in SB1 funds; requires 30% match • SHOPP: $1.5 billion in available funds; N/A match requirement	• SB 1 Information Page • SCCP Information Page • TCEP Information Page • SHOPP Information Page	1,2,3,8, 29-32, 35
California Public Utilities Commission California Advanced Services Fund (CASF)	Accepted on a rolling basis	• Rural city fiber installation	• No specified grant limit nor match limit	• CASF Application Process	20,22
California State Transportation Improvement Program (STIP)	Submittal on December 15th of Odd Numbered Years	• Transit and Rail Projects • Managed lanes project • HOT lanes	• Up to $3.28 billion of funding for FY 2019 • No specified match rate	• CTC STIP Information Page	1,2,3,8, 29-32, 35
California Transportation Commission Active Transportation Program (CTC ATP)	May 2019 Call for projects for Fiscal Years 19/20 – 22/23	• East Bay Greenway • Safe Route to School Programs	• $440 million of available funds, appropriated to each CA region • CTC does not require fund matching at state level	• CTC ATP Information Page • Caltrans ATP Application • SB1 ATP Information Page	5,6,27,28, 33

5.2.1.4 Federal Funding Programs

Federally funded transportation programs are typically administered by Caltrans, or the MPO, which distributes funds based on local policies or award programs. Some examples of federally-funded transportation programs are described below.

Surface Transportation Block Grant Program (STBG): The STBG is an approved funding program through at least 2020. Infrastructure-based ITS capital improvements, including the installation of vehicle-to-infrastructure communication equipment, are eligible for the grant. In addition, operational improvements (including capital and operations costs) for traffic operations facilities, environmental measures, and some parking strategies are eligible. The project must be identified in a Statewide Transportation Improvement Program (FSTIP) and be aligned by long range Metropolitan Transportation Plans.

Better Utilizing Investments to Leverage Development (BUILD) Grants: The BUILD program has replaced the Transportation Investment Generating Economic Recover (TIGER) grant program and grants are awarded on a competitive basis for projects with significant regional or local impacts. These grants are designed to benefit surface transportation systems while providing further support to rural communities. A greater share of BUILD grants will be awarded to projects located in rural areas.

Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD): ATCMTD is a competitive grant program that funds projects related to many ITS objectives. The grant serves to fund installation of transportation technologies that can improve efficiency, safety, and system performance. A state, local, transit, or Municipal Planning Area (MPA) agency is eligible to apply. In addition, a multijurisdictional group can apply with a signed agreement. A maximum of $60 million is available each fiscal year through 2020. A 50% minimum local match is required. Single project awards will not exceed $12 million and there will be between 5 and 10 grants awarded. Applications are invited during the Spring of each year.

Transportation Infrastructure Finance and Innovation Act (TIFIA): TIFIA is not a grant or traditional funding program but is a credit assistance program awarded to qualified projects of regional or national significance. TIFIA credit assistance is available to ITS projects of at least $15 million and the credit assistance is limited to 33% of the total eligible project costs. The interest rate for TIFIA projects are typically around 3% for urban projects and would decrease by half for rural projects. Repayment for TIFIA projects can be deferred for 5 years after the project's completion, the loan must be fully repaid after 25 years from the first payment.

Table 14: Federal Funding Programs

Program	Important Dates	Projects Funded	Max Funds/ Match Limits	Additional Info	Applicable Projects (Table 2)
Surface Transportation Block Grant Program (STBG)	Yearly application deadline around	• Operational improvements for traffic monitoring, management, and control facilities • Projects for congestion pricing, including electronic toll collection and travel demand management	• Allocates $11-12 billion a year of funding • Federal share can vary from 80-100%	• STBG Information Page	3-7,9-13, 21-28, 30, 33-36
Better Utilizing Investments to Leverage Development (BUILD) Grants	Yearly application deadline around Mid-July	• Public transportation • Highway projects • Freight rail projects • Port infrastructure improvements	• Max Grant: $25 million • May exceed 80% in rural areas	• BUILD Application	3-7,9-13, 30, 33, 34, 35
Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD)	Yearly application deadline around Mid-June	• Traveler information systems • Transportation management technologies • ITS integration with the grid • Advanced mobility technologies	• Projects can receive 12% of total available funds ($12 million in • Federal share of up to 50% of the cost of the project	• ATCMTD Information • ATCMT Deployment Initiative Application	1,2,3, 13-32, 35, 36
Transportation Infrastructure Finance and Innovation Act (TIFIA)	Application on a rolling basis	• Highway • Transit • Rail • Transit-Oriented development • ITS projects	• Can provide credit assistance amounting to 33% of project costs, • If sponsor provides a compelling justification, assistance may be increased to 49%	• TIFIA Program Overview • TIFIA Application Information	1-36

5.2.2 Public-Private Partnerships (P3s)

P3s are funding sources in which a private agency can collaborate with a public agency to fund the buildout of a project. In the P3 structures referred to in this document, private agencies provide funding in exchange for the use of public resources and can mutually benefit the parties involved. This section presents a selection of creative fiber P3s opportunities in which provide funding for fiber projects through the licensing of public equipment.

Licensing Conduit: Agencies with existing conduit can generate funding by leasing their conduit's right-of-way (ROW) to private or public agencies. In these licensing agreements, it is likely that the owning agency will cover the costs for operating and maintaining their conduit. Typically, the sharing partner will pay for the costs of implementing the fiber network to end users (e.g. connecting fiber to networking infrastructure, installing fiber in conduit, developing plans for fiber implementation).

In a case study, City of Lincoln, Nebraska leased their conduit to a private internet service provider (ISP) to generate funds to expand their city-owned conduit. Through the terms of this agreement, the ISP installed their fiber within the city's conduit and provided resources to connect city owned equipment (e.g., traffic signals, loop detectors, government owned buildings) to city hall by using fiber.

Licensing Existing Fiber Backbone: Agencies with an existing backbone network can generate funding by leasing out dark fiber strands to public or private agencies. In these licensing agreements, the owning agency is responsible for funding operating and maintaining the fiber backbone. The sharing partner will typically be expected to fund the expansion of their laterals from the leased backbone network.

In a case study, City of Huntsville, Alabama leased their fiber backbone network to a private ISP to generate funding to expand their fiber backbone, conduit. Through the terms of the agreement, Huntsville was able to provide funding for conduit and fiber expansion and the ISP was able to provide fiber to residents of city.

6 PROJECT PRIORITZATION

Prior to this section, the project team proposed communications technology alternatives and provided planning-level cost estimates and funding opportunities for projects within the document. To evaluate which project would be prioritized, the team created five qualitative measurements. Projects were split into phases based on their relevancy to the regional fiber backbone and their ease of implementation. This section will discuss the methodology of prioritizing the proposed project list based on criteria discussed below.

6.1 Project Prioritization Methodology

Projects were evaluated based on five prioritization criteria: project cost, availability of existing or planned infrastructure, level of coordination with partner agencies, ease of construction, and availability of funding sources. The prioritization evaluation was completed using the following process:

The methodology can be summarized as follows:

- Step 1: Criteria factors were developed and assigned a weighted value
- Step 2: The project evaluation criterion were assigned rankings from 1 to 5 for each project

- Step 3: The list of proposed projects was evaluated using the developed evaluation criteria on a scale of 1-5
- Step 4: The scores for each project were weighted and summed

6.1.1 Criteria Factors

After assessing all factors that may influence the project, the team determined the most relevant criteria factors. Projects were evaluated with the following criteria.

- Availability of existing/planned infrastructure – whether the limits of the project has an existing or planned fiber and/or conduit communications infrastructure
- Ease of construction – whether the construction is installing new communications, if so where are the communications being installed. A lower score reflects that it is harder to install communications in that environment (bridge, local roads, freeway).
- Project cost – based on the total cost of the project as tabulated in Section 5.1.2
- Availability of Funding Sources – the number funding sources that can potentially be used by the proposed project. A detailed breakdown of the number of regional, state, and federal funding sources identified for each project is provided in Appendix F.
- Congestion – if the limits of the project include a congested corridor. For this plan congested corridors are defined per MTCs Top 50 Congested Locations, 2017.
- Level of coordination with partner agencies required – how many agencies are required to coordinate the project

Each factor was given a weighting factor based on the level of importance as applied to the project. A higher percentage represents a more important criterion. Total weighting is 100%.

- Availability of existing/planned infrastructure – 30%
- Ease of construction – 20%
- Project cost – 20%
- Congestion – 15%
- Availability of Potential Funding Sources – 10%
- Level of coordination with partner agencies required – 5%

Project cost, availability of existing/planned infrastructure, and ease of construction are the most important criteria factors as they can present large obstacles to a project, and therefore should have a greater impact on a project's priority. Availability of existing/planned infrastructure has the greatest weight because it is in MTCs interest to leverage local infrastructure when creating the regional fiber network.

Ultimately this regional communications network will be used to mitigate congestion. Therefore, projects that are on congested corridors will influence a project's score. While it is also important to consider availability of potential funding sources and level of coordination with partner agencies required, these factors should differentiate projects that have similar scores and not have a large influence on overall ranking.

6.1.2 Criteria Factor Ranking

Each project was ranked from a minimum score of 1 and a maximum score of 5 for each of the criteria factors. After being assigned a score from 1-5 for each criterion, the scores will be weighed and summed for each project. The summed scores are also ranked from 1-5. Table 15 outlines each score one through five and how it relates to each criteria factor.

Table 15: Criteria Factor Ranking

	Project Scoring Criteria	Availability of Existing/Planned Infrastructure	Ease of Construction	Project Cost	Congestion	Availability of Potential Funding Sources	Level of Coordination with Partner Agencies
Criteria Score (1-5)	Criteria Weight	30%	20%	20%	15%	10%	5%
	1	* Corridor does not include planned or existing communications infrastructure	* New communications infrastructure is being built on a regional bridge structure and/or an environmentally sensitive area	> $5,000,000	* Project is not in the Top 50 Congested Locations	* Project can potentially receive funding from 0 to 1 source	* Coordination with 4 or more agencies required
	2	*Corridor includes existing communications conduit	* New communications infrastructure is being built primarily on local roads	$2,500,000 - $5,000,000	* Project is in the Top 31-50 Congested Locations	* Project can potentially receive funding from 2 sources	* Coordination with 3 agencies required
	3	*Corridor includes existing communications conduit and fiber	* New communications infrastructure is being built primarily along State Highway System (not on regional bridge structure)	$1,000,000 - $2,499,999	* Project is in the Top 21-30 Congested Locations	* Project can potentially receive funding from 3 sources	* Coordination with 2 agencies required
	4	*Corridor includes planned communications conduit	* New fiber communications infrastructure is being installed in existing conduit infrastructure	$200,000 - $999,999	* Project is in the Top 11-20 Congested Locations	* Project can potentially receive funding from 4 sources	* Coordination with 1 agency required
	5	*Corridor includes planned communications conduit and fiber	* No new communications infrastructure is being built	< $200,000	* Project is in the Top 1-10 Congested Locations	* Project can potentially receive funding from 5 or more sources	* Project is entirely within an agency's jurisdiction

6.2 Project Prioritization Results

Each project was assigned a value of one through five for each of the criteria factors. Then the values were weighed against each other based on the weighting assigned in Section 6.1.1. This produced an overall score for the project which was then used for ranking.

Table 16 shows the proposed projects relating to creating the regional communications network in order of their prioritization score. In Section 6.3 the projects are organized into consecutive phases.

Table 16: Prioritized Regional Communications Network Project List

Project Rank	Project	Project Type	Recommended Technology	Total Cost (Over 25 Years)	Project Costs	Availability of Existing or Planned Infrastructure	Level of Coordination	Ease of Construction	Potential Availability of Funding	Congestion	Score (Out of Five)
1	VTA/Caltrans to dedicate fiber strands installed as part of the planned SR 237 Express Lane project for regional communications purposes	Share Infrastructure	N/A	$ 427,000	4	5	3	5	5	3	4.40
2	VTA/Caltrans to dedicate fiber strands installed as part of the planned US 101 Express Lane Project for regional communications purposes	Share Infrastructure	N/A	$ 1,469,000	3	5	3	5	5	4	4.35
3	C/CAG/Caltrans to dedicate fiber strands installed as part of the planned US 101 Managed Lanes Project for regional communications purposes	Share Infrastructure	N/A	$ 2,859,000	2	5	3	5	5	4	4.15
4	BAIFA/Caltrans to dedicate existing fiber strands along I-880 from Hegenberger Road to Dixon Landing Road	Share Infrastructure	N/A	$ 3,206,000	2	3	3	5	3	4	3.35
5	City of Dublin to dedicate existing fiber strands for regional communications purposes to connect City of Dublin TMC to nearest regional fiber network connection point (I-580, San Ramon Road interchange)	Connect to TMC	Fiber Communications	$ 427,000	4	3	2	5	4	1	3.35
6	City of San Jose to dedicate existing fiber strands for regional communications purposes to connect SR 85 express lanes to nearest regional fiber network connection point (I-880, Zanker Road interchange)	Expresslanes	Fiber Communications	$ 1,817,000	3	3	2	5	5	1	3.25
7	Caltrans to make existing conduit infrastructure available for regional communications purposes along I-80 from Yerba Buena Island to Bay Bridge Toll Plaza	Share Infrastructure	N/A	$ 1,009,000	3	2	4	4	5	3	3.15
8	Caltrans to dedicate planned fiber strands for regional communications purposes to connect Caltrans D4 office to regional communications network connection (I-80, Bay Bridge Toll Plaza)	Connect to TMC	N/A	$ 659,000	4	4	4	2	4	1	3.15

Project Rank	Project	Project Type	Recommended Technology	Total Cost (Over 25 Years)	Project Costs	Availability of Existing or Planned Infrastructure	Level of Coordination	Ease of Construction	Potential Availability of Funding	Congestion	Score (Out of Five)
9	City of Fremont to dedicate existing fiber strands for regional communications purposes to connect City of Fremont TMC to nearest regional communications network connection point (I-880, Mowry Avenue interchange)	Connect to TMC	N/A	$ 427,000	4	3	5	2	4	1	2.90
10	County of Santa Clara to dedicate existing fiber strands for regional communications purposes to connect Digital Realty data center (San Jose) to nearest regional communications network point (SR 237, Lawrence Expressway interchange)	Connect to Data Center	N/A	$ 659,000	4	3	4	2	4	1	2.85
11	City of San Jose to dedicate existing fiber strands for regional communications purposes to connect VTA headquarters (San Jose) to nearest regional communications network point (SR 237, Zanker Road interchange)	Connect to Transit Center	N/A	$ 1,006,000	3	3	4	2	5	1	2.75
12	City of San Jose to dedicate existing fiber strands for regional communications purposes to connect City of San Jose TMC to nearest regional communications network connection point (SR 237, Zanker Road interchange)	Connect to TMC	N/A	$ 1,006,000	3	3	5	2	4	1	2.70
13	Install communications infrastructure along US 101 from Grand Avenue, South San Francisco to I-80	Install Infrastructure	Fiber Communications	$ 9,841,000	1	1	4	3	4	5	2.45
14	Install communications infrastructure along I-80 and I-880 from the Bay Bridge Toll Plaza to Hegenberger Road	Install Infrastructure	Fiber Communications	$ 12,301,000	1	1	4	3	4	5	2.45
15	Install communications infrastructure along I-80 from the Carquinez bridge to I-580	Install Infrastructure	Fiber Communications	$ 18,591,000	1	1	4	3	4	5	2.45
16	Install communications infrastructure along I-880 from Dixon Landing Road to SR 237	Install Infrastructure	Fiber Communications	$ 2,460,000	3	1	3	3	4	2	2.35
17	Install communications infrastructure along SR 237 from I-880 to North 1st Street	Install Infrastructure	Fiber Communications	$ 2,460,000	3	1	3	3	4	2	2.35

Project Rank	Project	Project Type	Recommended Technology	Total Cost (Over 25 Years)	Project Costs	Availability of Existing or Planned Infrastructure	Level of Coordination	Ease of Construction	Potential Availability of Funding	Congestion	Score (Out of Five)
18	Install communications infrastructure to nearest regional communications network connection point (I-880/SR 238 interchange) along I-580 from I-680 to SR 238 and along SR 238 from I-580 to the I-880	Expresslanes	Fiber Communications	$ 12,395,000	1	1	2	3	5	4	2.30
19	Install communications infrastructure to connect Sunol express lanes to nearest regional communications network connection point (I-880/SR 262 interchange) along SR 262 from I-680 to I-880	Install Infrastructure	Fiber Communications	$ 1,215,000	3	1	3	3	5	1	2.30
20	Connect Digital Realty data center (Oakland) to nearest regional communications network connection point (I-880, Webster Street interchange)	Connect to Data Center	Fiber Communications	$ 694,000	4	1	4	2	4	1	2.25
21	Connect Digital Realty data center (San Francisco) to nearest regional communications network connection point (US 101, 3rd Street interchange)	Connect to Data Center	Fiber Communications	$ 694,000	4	1	4	2	4	1	2.25
22	Connect City of Oakland TMC to nearest regional communications network connection point (I-880, Broadway interchange)	Connect to TMC	Fiber Communications	$ 694,000	4	1	4	2	4	1	2.25
23	Create redundant loop for the regional communications network across the San Mateo Bridge	Share Infrastructure/ Install Fiber	N/A	$ 6,904,000	1	2	2	1	5	4	2.20
24	Install communications infrastructure along I-80 from US 101 to Yerba Buena Island	Install Infrastructure	Fiber Communications	$ 6,155,000	1	1	4	1	5	5	2.15
25	Connect AC Transit headquarters (Oakland) to nearest regional communications network connection point (I-880, Broadway interchange)	Connect to Transit Center	Fiber Communications	$ 810,000	4	1	4	2	3	1	2.15
26	Connect Samtrans/Caltrain headquarters (San Carlos) to nearest regional communications network connection point (US 101, Holly Street interchange)	Connect to Transit Center	Fiber Communications	$ 925,000	4	1	4	2	3	1	2.15
27	Connect LAVTA headquarters (Livermore) to nearest regional communications network connection point (I-580, Isabel Avenue interchange)	Connect to Transit Center	Fiber Communications	$ 1,041,000	3	1	4	2	4	1	2.05

Project Rank	Project	Project Type	Recommended Technology	Total Cost (Over 25 Years)	Project Costs	Availability of Existing or Planned Infrastructure	Level of Coordination	Ease of Construction	Potential Availability of Funding	Congestion	Score (Out of Five)
28	Connect City of San Francisco TMC to nearest regional communications network connection point (US 101/I-80 interchange)	Connect to TMC	Fiber Communications	$ 1,156,000	3	1	4	2	4	1	2.05
29	Connect SFMTA headquarters (San Francisco) to nearest regional communications network connection point (US 101/I-80 interchange)	Connect to Transit Center	Fiber Communications	$ 1,156,000	3	1	4	2	3	1	1.95
30	Connect BART headquarters (Oakland) to nearest regional communications network connection point (I-880, Broadway interchange)	Connect to Transit Center	Fiber Communications	$ 1,156,000	3	1	4	2	3	1	1.95
31	Connect WestCAT headquarters (Pinole) to nearest regional communications network connection point (I-80, Appian Way interchange)	Connect to Transit Center	Fiber Communications	$ 2,314,000	3	1	4	2	3	1	1.95
32	Create redundant loop for the regional communications network across the Dumbarton Bridge	Share Infrastructure/ Install Fiber	N/A	$ 4,057,000	2	2	2	1	5	1	1.95
33	Install communications infrastructure to connect STA I-80 express lanes to nearest regional communications network connection point (Carquinez Bridge) along I-80 from SR 12 to Carquinez Bridge	Expresslanes	Fiber Communications	$ 15,492,000	1	1	3	3	5	1	1.90
34	Install communications infrastructure to connect SR 37 managed lanes to nearest regional communications network connection point (I-80) along SR 37 from Railroad Avenue to I-80	Expresslane	Fiber Communications	$ 6,075,000	1	1	3	3	5	1	1.90
35	Connect SolTrans headquarters (Vallejo) to nearest regional communications network connection point (I-80, Carquinez Bridge)	Connect to Transit Center	Fiber Communications	$ 3,470,000	2	1	4	2	4	1	1.85
36	Install communications infrastructure along the Carquinez Bridge	Install Infrastructure	Fiber Communications	$ 2,781,000	2	1	4	1	5	1	1.75

6.3 Phasing

Based on the goals of this plan and proposed projects the following phases are recommended:

- Phase 1: Share infrastructure to contribute to completing the fiber backbone
- Phase 2: Install infrastructure to contribute to completing the fiber backbone
- Phase 3: Install and share infrastructure to build out the regional communications network along highways
- Phase 4: Install and share infrastructure to build out the regional communications network along local roads

Projects may run concurrently depending on sponsors and funding sources.

6.3.1 Phase 1

Table 17 shows projects to be completed in the near future to complete the regional fiber backbone. These projects are low-hanging fruit and should be considered first. The total cost of the projects in this phase is $11,214,000.

Table 17: High-Priority Projects

Project Rank	Project	Total Cost (Over 25 Years)	Project Costs	Availability of Existing or Planned Infrastructure	Level of Coordination	Ease of Construction	Availability of Funding	Congestion	Score (Out of Five)
1-1	VTA/Caltrans to dedicate fiber strands installed as part of the planned SR 237 Express Lane project for regional communications purposes	$ 427,000	4	5	3	5	5	3	4.40
1-2	VTA/Caltrans to dedicate fiber strands installed as part of the planned US 101 Express Lane Project for regional communications purposes	$ 1,469,000	3	5	3	5	5	4	4.35
1-3	C/CAG/Caltrans to dedicate fiber strands installed as part of the planned US 101 Managed Lanes Project for regional communications purposes	$ 2,859,000	2	5	3	5	5	4	4.15
1-4	BAIFA/Caltrans to dedicate existing fiber strands along I-880 from Hegenberger Road to Dixon Landing Road	$ 3,206,000	2	3	3	5	3	4	3.35
1-5	Caltrans to make existing conduit infrastructure available for regional communications purposes along I-80 from Yerba Buena Island to Bay Bridge Toll Plaza	$ 1,009,000	3	2	4	4	5	3	3.15

6.3.2 Phase 2

Table 18 shows projects to be completed in the midterm to complete the regional fiber backbone. The total cost of the projects in this phase is $74,404,000.

Table 18: Midterm Projects

Project Rank	Project	Total Cost (Over 25 Years)	Project Costs	Availability of Existing or Planned Infrastructure	Level of Coordination	Ease of Construction	Availability of Funding	Congestion	Score (Out of Five)
2-1	Install communications infrastructure along US 101 from Grand Avenue, South San Francisco to I-80	$ 9,841,000	1	1	4	3	4	5	2.45

Project Rank	Project	Total Cost (Over 25 Years)	Project Costs	Availability of Existing or Planned Infrastructure	Level of Coordination	Ease of Construction	Availability of Funding	Congestion	Score (Out of Five)
2-2	Install communications infrastructure along I-80 and I-880 from the Bay Bridge Toll Plaza to Hegenberger Road	$ 12,301,000	1	1	4	3	4	5	2.45
2-3	Install communications infrastructure along I-880 from Dixon Landing Road to SR 237	$ 2,460,000	3	1	3	3	4	2	2.35
2-4	Install communications infrastructure along SR 237 from I-880 to North 1st Street	$ 2,460,000	3	1	3	3	4	2	2.35
2-5	Install communications infrastructure to connect Sunol express lanes to nearest regional communications network connection point (I-880/SR 262 interchange) along SR 262 from I-680 to I-880	$ 1,215,000	3	1	3	3	5	1	2.30
2-6	Install communications infrastructure along I-80 from US 101 to Yerba Buena Island	$ 6,155,000	1	1	4	1	5	5	2.15

6.3.3 Phase 3

Table 19 shows projects are to be completed in the long term. Phase 3 projects help build-out the regional communications network along freeways. These projects are independent of each other. Sponsor to use best judgement when determining whether it is appropriate to complete projects before completion of Phases 1 and 2. The total cost of the projects in this phase is $92,695,000.

Table 19: Midterm Projects

Project Rank	Project	Total Cost (Over 25 Years)	Project Costs	Availability of Existing or Planned Infrastructure	Level of Coordination	Ease of Construction	Availability of Funding	Congestion	Score (Out of Five)
3-1	Install communications infrastructure along I-80 from the Carquinez bridge to I-580	$ 18,591,000	1	1	4	3	4	5	2.45
3-2	Install communications infrastructure to nearest regional communications network connection point (I-880/SR 238 interchange) along I-580 from I-680 to SR 238 and along SR 238 from I-580 to the I-880	$ 12,395,000	1	1	2	3	5	4	2.30
3-3	Create redundant loop for the regional communications network across the San Mateo Bridge	$ 6,904,000	1	2	2	1	5	4	2.20
3-4	Create redundant loop for the regional communications network across the Dumbarton Bridge	$ 4,057,000	2	2	2	1	5	1	1.95
3-5	Install communications infrastructure to connect STA I-80 express lanes to nearest regional communications network connection point (Carquinez Bridge) along I-80 from SR 12 to Carquinez Bridge	$ 15,492,000	1	1	3	3	5	1	1.90

Project Rank	Project	Total Cost (Over 25 Years)	Project Costs	Availability of Existing or Planned Infrastructure	Level of Coordination	Ease of Construction	Availability of Funding	Congestion	Score (Out of Five)
3-6	Install communications infrastructure along the Carquinez Bridge	$ 2,781,000	2	1	4	1	5	1	1.75

6.3.4 Phase 4

Table 20 shows projects are to be completed in the long term. Phase 4 projects are mostly along local roads and require the regional fiber network along highways to be built out. These projects are independent of each. Sponsor to use best judgement when determining whether it is appropriate to complete projects before completion of Phases 1, 2, and 3. The total cost of the projects in this phase is $119,066,000.

Table 20: Long-Term Projects

Project Rank	Project	Total Cost (Over 25 Years)	Project Costs	Availability of Existing or Planned Infrastructure	Level of Coordination	Ease of Construction	Availability of Funding	Congestion	Score (Out of Five)
4-1	City of Dublin to dedicate existing fiber strands for regional communications purposes to connect City of Dublin TMC to nearest regional fiber network connection point (I-580, San Ramon Road interchange)	$ 427,000	4	3	2	5	4	1	3.35
4-2	City of San Jose to dedicate existing fiber strands for regional communications purposes to connect SR 85 express lanes to nearest regional fiber network connection point (I-880, Zanker Road interchange)	$ 1,817,000	3	3	2	5	5	1	3.25
4-3	Caltrans to dedicate planned fiber strands for regional communications purposes to connect Caltrans D4 office to regional communications network connection (I-80, Bay Bridge Toll Plaza)	$ 659,000	4	4	4	2	4	1	3.15
4-4	City of Fremont to dedicate existing fiber strands for regional communications purposes to connect City of Fremont TMC to nearest regional communications network connection point (I-880, Mowry Avenue interchange)	$ 427,000	4	3	5	2	4	1	2.90
4-5	County of Santa Clara to dedicate existing fiber strands for regional communications purposes to connect Digital Realty data center (San Jose) to nearest regional communications network point (SR 237, Lawrence Expressway interchange)	$ 659,000	4	3	4	2	4	1	2.85
4-6	City of San Jose to dedicate existing fiber strands for regional communications purposes to connect VTA headquarters (San Jose) to nearest regional communications network point (SR 237, Zanker Road interchange)	$ 1,006,000	3	3	4	2	5	1	2.75
4-7	City of San Jose to dedicate existing fiber strands for regional communications purposes to connect City of San Jose TMC to nearest regional communications network connection point (SR 237, Zanker Road interchange)	$ 1,006,000	3	3	5	2	4	1	2.70

Project Rank	Project	Total Cost (Over 25 Years)	Project Costs	Availability of Existing or Planned Infrastructure	Level of Coordination	Ease of Construction	Availability of Funding	Congestion	Score (Out of Five)
4-8	Connect Digital Realty data center (Oakland) to nearest regional communications network connection point (I-880, Webster Street interchange)	$ 694,000	4	1	4	2	4	1	2.25
4-9	Connect Digital Realty data center (San Francisco) to nearest regional communications network connection point (US 101, 3rd Street interchange)	$ 694,000	4	1	4	2	4	1	2.25
4-10	Connect City of Oakland TMC to nearest regional communications network connection point (I-880, Broadway interchange)	$ 694,000	4	1	4	2	4	1	2.25
4-11	Connect AC Transit headquarters (Oakland) to nearest regional communications network connection point (I-880, Broadway interchange)	$ 810,000	4	1	4	2	3	1	2.15
4-12	Connect Samtrans/Caltrain headquarters (San Carlos) to nearest regional communications network connection point (US 101, Holly Street interchange)	$ 925,000	4	1	4	2	3	1	2.15
4-13	Connect LAVTA headquarters (Livermore) to nearest regional communications network connection point (I-580, Isabel Avenue interchange)	$ 1,041,000	3	1	4	2	4	1	2.05
4-14	Connect City of San Francisco TMC to nearest regional communications network connection point (US 101/I-80 interchange)	$ 1,156,000	3	1	4	2	4	1	2.05
4-15	Connect SFMTA headquarters (San Francisco) to nearest regional communications network connection point (US 101/I-80 interchange)	$ 1,156,000	3	1	4	2	3	1	1.95
4-16	Connect BART headquarters (Oakland) to nearest regional communications network connection point (I-880, Broadway interchange)	$ 1,156,000	3	1	4	2	3	1	1.95
4-17	Connect WestCAT headquarters (Pinole) to nearest regional communications network connection point (I-80, Appian Way interchange)	$ 2,314,000	3	1	4	2	3	1	1.95
4-18	Install communications infrastructure to connect SR 37 managed lanes to nearest regional communications network connection point (I-80) along SR 37 from Railroad Avenue to I-80	$ 6,075,000	1	1	3	3	5	1	1.90
4-19	Connect SolTrans headquarters (Vallejo) to nearest regional communications network connection point (I-80, Carquinez Bridge)	$ 3,470,000	2	1	4	2	4	1	1.85

Figure 11 on the next page shows the phasing of the proposed projects.

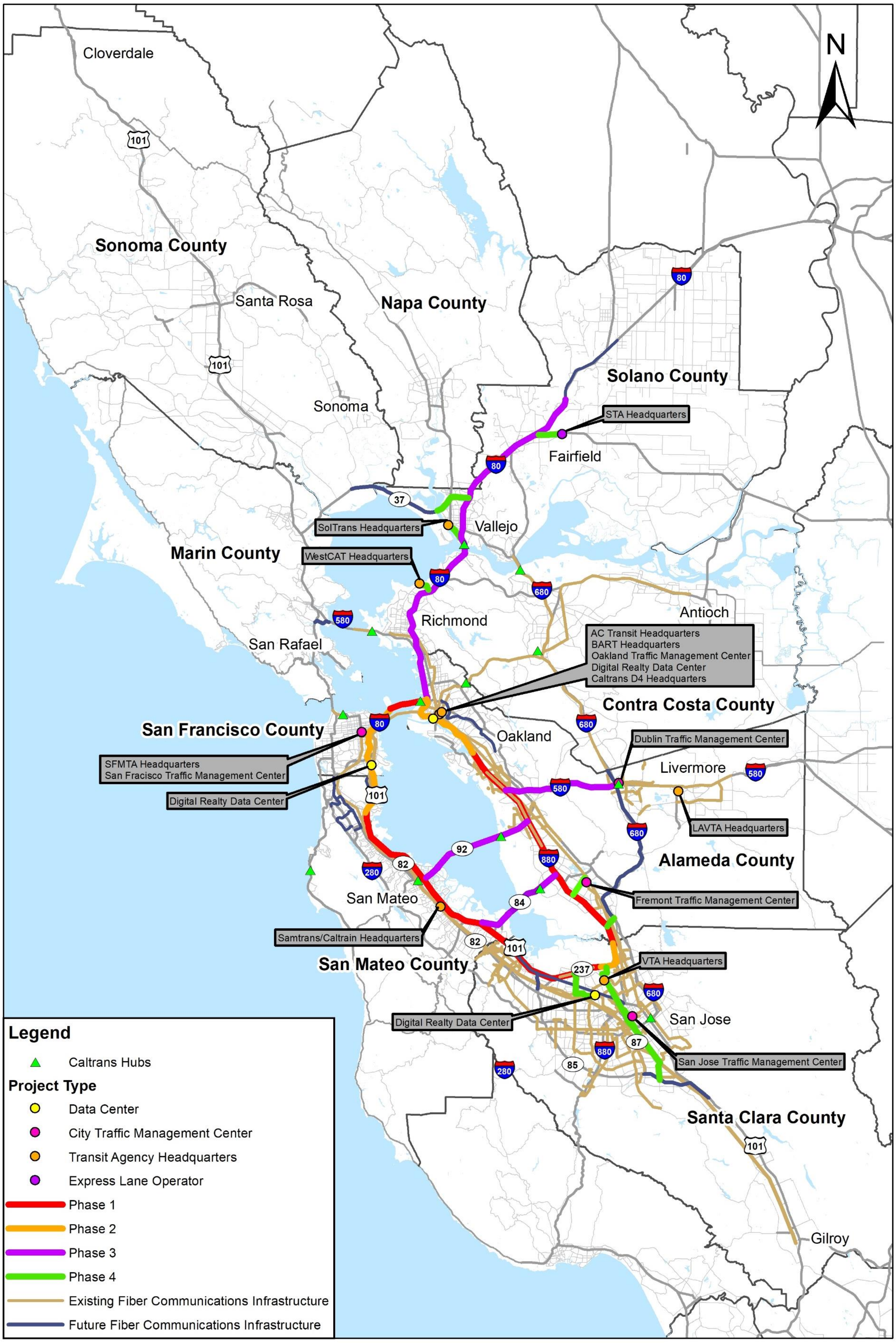

Figure 11: Proposed Project Phasing

7 NEXT STEPS

Stakeholders are encouraged to integrate communications in all stages of project development. It is crucial to the success of the regional communications network for different agencies and departments to coordinate and leverage their investments. Development of Dig Smart or Dig Once policies will help mainstream fiber communications infrastructure deployment and could be used to develop and expand the regional communications network. Also, it is suggested that agencies develop best practices for procuring communications network infrastructure.

The details of day-to-day regional communications network management and funding are to be determined. Detailed design parameters (e.g. infrastructure security, throughout as-built documentation, pull box spacing) will be defined as each project moves into implementation. Many proposed projects include agencies sharing infrastructure. For those situations, it is important to develop asset protection and maintenance guidelines to protect investments.

8 APPENDICES

Appendix A: Communications Technology Selection Methodology

	Fiber	Description	Leased Comm	Description	High-Speed Wireless	Description	Low-Speed Wireless	Description
< 1 device per mile	-2	Data transmission speed and reliability are rarely critical in this scenario; therefore, the benefit of a fiber connection is low.	2	Level of investment is low relative to the benefit of having a communications connection out to devices in this scenario.	-2	Data transmission speed and reliability are rarely critical in this scenario; therefore, the benefit of a high-speed wireless connection is low.	1	Level of investment is relatively low; however, investment in an agency-owned communications network for this level of device density may be considered significant, unless the agency intends to scale number of devices up in the future.
< 5 devices per mile	-1	Data transmission speed and reliability are typically not critical in this scenario; therefore, the benefit of a fiber connection is low.	1	Level of investment is low relative to the benefit of having a communications connection out to devices in this scenario. However, depending on the type of devices and how important the data is, investing in an agency-owned network may be justified.	-1	Data transmission speed and reliability are typically not critical in this scenario; therefore, the benefit of a high-speed wireless connection is low.	0	Level of investment is relatively low; however, investment in an agency-owned communications network for this level of device density may be considered significant.
> 5 devices per mile	3	Data transmission speed and reliability are likely critical in this scenario; therefore, investment in an agency-owned fiber connection may be justified.	0	For this level of device density, while leased communications provides a technically sufficient solution, it may not be the most effective solution long-term.	2	Data transmission speed and reliability are likely critical in this scenario; therefore, investment in an agency-owned high-speed wireless connection may be justified. All things equal, this alternative is less desirable than a hardwired fiber connection.	-3	Data transmission speed and reliability are likely critical in this scenario; therefore, investment in an agency-owned low-speed communications network is not justifiable.
CCTV Cameras	3	Data transmission speed and reliability are likely critical in this scenario; therefore, investment in an agency-owned fiber connection may be justified.	1	Leased communications provide varying levels of bandwidth based on a customer's needs. Therefore, the CCTV owner can much more easily scale their needs through a leased communications network, than through building their own network. However, leased communications are less desirable for high-bandwidth devices relative to agency owned communications.	1	Data transmission speed and reliability are likely critical in this scenario; therefore, investment in an agency-owned high-speed wireless connection may be justified. All things equal, this alternative is less desirable than a hardwired fiber connection.	-3	Data transmission speed and reliability are likely critical in this scenario; therefore, investment in an agency-owned low-speed communications network is not justifiable.

	Fiber	Description	Leased Comm	Description	High-Speed Wireless	Description	Low-Speed Wireless	Description
Freeway	3	Fiber infrastructure is easiest to construct along freeway right-of-way.	-1	Leased communications can typically be more difficult to access along freeway corridors relative to arterials.	2	Wireless communications infrastructure is easier to construct along freeway right-of-way.	1	Wireless communications infrastructure is easier to construct along freeway right-of-way. Low-speed wireless communications requires installation of more wireless infrastructure to carry the same amount of data as compared to high-speed wireless; therefore, construction impacts are likely more significant.
Existing ITS Technology Corridor	3	Fiber communications provides adequate bandwidth capacity for any existing ITS technology.	2	Leased communications can provide scalable bandwidth based on existing bandwidth needs along a particular corridor.	-1	High-speed wireless communications provide adequate bandwidth capacity for any existing ITS technology; however, constructability may be an issue along an existing corridor.	-2	Not ideal for ITS-specific corridor applications due to low-bandwidth.
Planned ITS Technology Corridor	3	Fiber communications provides adequate communications for any existing ITS technology.	1	The level of leased communications necessary to accommodate planned technologies can be defined in advance, specific to availability of leased line communications in a specific location.	0	High-speed wireless can be designed in advance to accommodate planned ITS technologies. However, it is less reliable that fiber therefore less beneficial.	-3	Not ideal for ITS-specific corridor applications due to low-bandwidth.
Near term construction (less than 24 months)	3	Fiber installation can be added relatively easily to design of freeway projects.	0	No benefit or dis-benefit in this scenario.	1	Wireless infrastructure installation may be added to freeway projects, but the design and implementation of these systems are more specialized than fiber projects.	1	Wireless infrastructure installation may be added to freeway projects, but the design and implementation of these systems are more specialized than fiber projects.
Less than 2 miles from Backbone	3	There is higher value in extending an existing nearby communications backbone.	-3	There is likely higher value in connecting to a nearby fiber communications network, compared to paying for leased communications services.	2	There is value in extending a nearby backbone via high-speed wireless communications; however, that value is less than if the network is extended via fiber backbone.	-3	Implementation of a low-speed communications network negates the value of being close to a high-speed backbone network.

	Fiber	Description	Leased Comm	Description	High-Speed Wireless	Description	Low-Speed Wireless	Description
More than 2 miles from Backbone	1	There is less value in building a new wired communications network if there are no backbone connections nearby.	1	The value of this option is directly related to the distance between the communication backbone and the new communications network location. The further away, the more attractive the leased communication option is.	2	Extending an existing backbone via high-speed (high-bandwidth) wireless communications network can be of comparable value to extending the backbone via wired communications, at a fraction of the investment.	0	There is little value in connecting to an existing backbone via a low-speed wireless link.
Less than 2 miles from BART	3	There is higher value in connecting to BART fiber via a new fiber communications network.	-3	The use of leased communications negates the value of being close to BART fiber access.	2	There is value in connecting to BART fiber via high-speed wireless communications; however, that value is less than if connecting to BART via fiber.	-3	Implementation of a low-speed communications network negates the value of being close to a high-speed backbone network.
More than 2 miles from BART	1	There is less value in building a new wired communications network if there is no BART connection nearby.	1	The value of this option is directly related to the distance between the BART connection and the new communications network location. The further away, the more attractive the leased communication option is.	2	Connecting to the BART network via high-speed (high-bandwidth) wireless communications network can be of comparable value to tying into the BART network via wired communications, at a fraction of the investment.	0	There is little value in connecting to BART fiber via a low-speed wireless link.
Environmentally sensitive area	-2	Construction of fiber infrastructure requires significant ground disturbance.	2	Leased communications are typically already in place, and usually require minimal additional construction to access.	2	High-speed wireless infrastructure is minimally disruptive relative to wired communications infrastructure installation.	1	Low-speed wireless infrastructure is minimally disruptive relative to wired communications infrastructure installation. But, low-speed wireless requires installation of more wireless infrastructure to carry the same amount of data as compared to high-speed wireless.
Bridge crossing	-2	Wired communications along a bridge presents constructability challenges	1	This option eliminates constructability concerns.	2	This option eliminates constructability concerns.	1	This option eliminates constructability concerns.

Appendix B: Technology Section Appendix

Project #4

The corridor has the following characteristics:

- Equipped with 6 devices per mile
- Monitored by CCTV cameras
- Along a freeway
- Not along an existing ITS technology corridor
- Not along a planned ITS technology corridor
- Not along a route that has near term construction
- Less than 2 miles from a backbone access point (C/CAG Smart Corridor – at San Bruno Avenue US 101 Interchange)
- Less than 2 miles from a BART access point (San Bruno, Glen Park)
- Not crossing through an environmentally sensitive area
- No bridge crossings

The scoring matrix results for this project are shown in Table 1.

Table 1: Scoring Matrix of Weighted Values for Project 4

	Fiber	Leased Comm	High-Speed Wireless	Low-Speed Wireless
< 1 device per mile	N/A	N/A	N/A	N/A
1-5 devices per mile	N/A	N/A	N/A	N/A
> 5 devices per mile	**3**	**0**	**2**	**-3**
CCTV Cameras	**3**	**1**	**1**	**-3**
Freeway	**3**	**-1**	**2**	**3**
Existing ITS Technology Corridor	N/A	N/A	N/A	N/A
Planned ITS Technology Corridor	N/A	N/A	N/A	N/A
Near term construction (less than 24 months)	N/A	N/A	N/A	N/A
Less than 2 miles from Backbone	**3**	**-3**	**2**	**-3**
More than 2 miles from Backbone	N/A	N/A	N/A	N/A
Less than 2 miles from BART	**3**	**-3**	**2**	**-3**
More than 2 miles from BART	N/A	N/A	N/A	N/A
Environmentally sensitive area	N/A	N/A	N/A	N/A
Bridge crossing	N/A	N/A	N/A	N/A
Total Score	**15**	**-6**	**9**	**-9**

Based on this analysis, fiber communications is the most appropriate communications alternative for this project.

Table 2: Final Scoring Matrix Results for Project 4

Fiber	15
Leased Communications	-6
High-Speed Wireless	9
Low-Speed Wireless	-9

Project #5

The corridor has the following characteristics:

- Equipped with 6 devices per mile
- Monitored by CCTV cameras
- Along a freeway
- Not along an existing ITS technology corridor
- Not along a planned ITS technology corridor
- Not along a route that has near term construction
- Less than 2 miles from a backbone access point (Existing Caltrans Infrastructure - Yerba Buena Island)
- Less than 2 miles from a BART access point (Powell)
- Not crossing through an environmentally sensitive area
- Bridge crossing (Bay Bridge)

The scoring matrix results for this project are shown in Table 3.

Table 3: Scoring Matrix of Weighted Values for Project 5

	Fiber	Leased Comm	High-Speed Wireless	Low-Speed Wireless
< 1 device per mile	N/A	N/A	N/A	N/A
1-5 devices per mile	N/A	N/A	N/A	N/A
> 5 devices per mile	**3**	**0**	**2**	**-3**
CCTV Cameras	**3**	**1**	**1**	**-3**
Freeway	**3**	**-1**	**2**	**3**
Existing ITS Technology Corridor	N/A	N/A	N/A	N/A
Planned ITS Technology Corridor	N/A	N/A	N/A	N/A
Near term construction (less than 24 months)	N/A	N/A	N/A	N/A
Less than 2 miles from Backbone	**3**	**-3**	**2**	**-3**
More than 2 miles from Backbone	N/A	N/A	N/A	N/A
Less than 2 miles from BART	**3**	**-3**	**2**	**-3**
More than 2 miles from BART	N/A	N/A	N/A	N/A
Environmentally sensitive area	N/A	N/A	N/A	N/A
Bridge crossing	**-2**	**1**	**2**	**1**
Total Score	**12**	**-5**	**11**	**-8**

Based on this analysis, fiber communications is the most appropriate communications alternative for this project.

Table 4: Final Scoring Matrix Results for Project 5

Fiber	13
Leased Communications	-5
High-Speed Wireless	11
Low-Speed Wireless	-8

Project #7

The corridor has the following characteristics:

- Equipped with 6 devices per mile
- Monitored by CCTV cameras
- Along a freeway
- Not along an existing ITS technology corridor
- Not along a planned ITS technology corridor
- Not along a route that has near term construction
- Less than 2 miles from a backbone access point (East Bay BRT Fiber, I-880 Express Lane at Hegenberger Road, Oakland)
- Less than 2 miles from a BART access point (12th St/Oakland)
- Not crossing through an environmentally sensitive area
- Bridge crossing (Lake Merritt, San Leandro Bay)

The scoring matrix results for this project are shown in Table 5.

Table 5: Scoring Matrix of Weighted Values

	Fiber	Leased Comm	High-Speed Wireless	Low-Speed Wireless
< 1 device per mile	N/A	N/A	N/A	N/A
1-5 devices per mile	N/A	N/A	N/A	N/A
> 5 devices per mile	**3**	**0**	**2**	**-3**
CCTV Cameras	**3**	**1**	**1**	**-3**
Freeway	**3**	**-1**	**2**	**3**
Existing ITS Technology Corridor	N/A	N/A	N/A	N/A
Planned ITS Technology Corridor	N/A	N/A	N/A	N/A
Near term construction (less than 24 months)	N/A	N/A	N/A	N/A
Less than 2 miles from Backbone	**3**	**-3**	**2**	**-3**
More than 2 miles from Backbone	N/A	N/A	N/A	N/A
Less than 2 miles from BART	**3**	**-3**	**2**	**-3**
More than 2 miles from BART	N/A	N/A	N/A	N/A
Environmentally sensitive area	N/A	N/A	N/A	N/A
Bridge crossing	**-2**	**1**	**2**	**1**
Total Score	**12**	**-5**	**11**	**-8**

Based on this analysis, fiber communications is the most appropriate communications alternative for this project.

Table 6: Final Scoring Matrix Results

Fiber	13
Leased Communications	-5
High-Speed Wireless	11
Low-Speed Wireless	-8

Project #9

The corridor has the following characteristics:

- Equipped with 6 devices per mile
- Monitored by CCTV cameras
- Along a freeway
- Along an existing ITS technology corridor
- Not along a planned ITS technology corridor
- Not along a route that has near term construction
- Less than 2 miles from a backbone access point (I-880 Express Lanes - Dixon Landing Road, Milpitas)
- More than 2 miles from a BART access point
- Not crossing through an environmentally sensitive area
- No bridge crossings

The scoring matrix results for this project are shown in Table 7.

Table 7: Scoring Matrix of Weighted Values

	Fiber	Leased Comm	High-Speed Wireless	Low-Speed Wireless
< 1 device per mile	N/A	N/A	N/A	N/A
1-5 devices per mile	N/A	N/A	N/A	N/A
> 5 devices per mile	**3**	**0**	**2**	**-3**
CCTV Cameras	**3**	**1**	**1**	**-3**
Freeway	**3**	**-1**	**2**	**3**
Existing ITS Technology Corridor	**3**	**2**	**-1**	**-2**
Planned ITS Technology Corridor	N/A	N/A	N/A	N/A
Near term construction (less than 24 months)	N/A	N/A	N/A	N/A
Less than 2 miles from Backbone	**3**	**-3**	**2**	**-3**
More than 2 miles from Backbone	N/A	N/A	N/A	N/A
Less than 2 miles from BART	N/A	N/A	N/A	N/A
More than 2 miles from BART	**1**	**1**	**2**	**0**
Environmentally sensitive area	N/A	N/A	N/A	N/A
Bridge crossing	N/A	N/A	N/A	N/A
Total Score	**15**	**0**	**8**	**-8**

Based on this analysis, fiber communications is the most appropriate communications alternative for this project.

Table 8: Final Scoring Matrix Results

Fiber	16
Leased Communications	0
High-Speed Wireless	8
Low-Speed Wireless	-8

Project #10

The corridor has the following characteristics:

- Equipped with 6 devices per mile
- Monitored by CCTV cameras
- Along a freeway
- Along an existing ITS technology corridor
- Not along a planned ITS technology corridor
- Not along a route that has near term construction
- Less than 2 miles from a backbone access point (I-880 Express Lanes - Dixon Landing Road, Milpitas)
- More than 2 miles from a BART access point
- Not crossing through an environmentally sensitive area
- Bridge crossings at Coyote Creek, Guadalupe River, Saratoga Creek

The scoring matrix results for this project are shown in Table 9.

Table 9: Scoring Matrix of Weighted Values

	Fiber	Leased Comm	High-Speed Wireless	Low-Speed Wireless
< 1 device per mile	N/A	N/A	N/A	N/A
1-5 devices per mile	N/A	N/A	N/A	N/A
> 5 devices per mile	**3**	**0**	**2**	**-3**
CCTV Cameras	**3**	**1**	**1**	**-3**
Freeway	**3**	**-1**	**2**	**3**
Existing ITS Technology Corridor	**3**	**2**	**-1**	**-2**
Planned ITS Technology Corridor	N/A	N/A	N/A	N/A
Near term construction (less than 24 months)	N/A	N/A	N/A	N/A
Less than 2 miles from Backbone	**3**	**-3**	**2**	**-3**
More than 2 miles from Backbone	N/A	N/A	N/A	N/A
Less than 2 miles from BART	N/A	N/A	N/A	N/A
More than 2 miles from BART	**1**	**1**	**2**	**0**
Environmentally sensitive area	N/A	N/A	N/A	N/A
Bridge crossing	**-2**	**1**	**2**	**1**
Total Score	**13**	**1**	**10**	**-7**

Based on this analysis, fiber communications is the most appropriate communications alternative for this project.

Table 10: Final Scoring Matrix Results

Fiber	14
Leased Communications	1
High-Speed Wireless	10
Low-Speed Wireless	-7

Projects #11, 12, 15, 16, 18, 23, and 25

The corridor has the following characteristics:

- Equipped with 1-5 devices per mile
- Monitored by CCTV cameras
- Not along a freeway
- Not along an existing ITS technology corridor
- Not along a planned ITS technology corridor
- Not along a route that has near term construction
- Less than 2 miles from a backbone access point
- Less than 2 miles from a BART access point
- Not crossing through an environmentally sensitive area
- No bridge crossings

The scoring matrix results for this project are shown in Table 11.

Table 11: Scoring Matrix of Weighted Values

	Fiber	Leased Comm	High-Speed Wireless	Low-Speed Wireless
< 1 device per mile	N/A	N/A	N/A	N/A
1-5 devices per mile	**-1**	**1**	**-1**	**0**
> 5 devices per mile	N/A	N/A	N/A	N/A
CCTV Cameras	**3**	**1**	**1**	**-3**
Freeway	N/A	N/A	N/A	N/A
Existing ITS Technology Corridor	N/A	N/A	N/A	N/A
Planned ITS Technology Corridor	N/A	N/A	N/A	N/A
Near term construction (less than 24 months)	N/A	N/A	N/A	N/A
Less than 2 miles from Backbone	**3**	**-3**	**2**	**-3**
More than 2 miles from Backbone	N/A	N/A	N/A	N/A
Less than 2 miles from BART	**3**	**-3**	**2**	**-3**
More than 2 miles from BART	N/A	N/A	N/A	N/A
Environmentally sensitive area	N/A	N/A	N/A	N/A
Bridge crossing	N/A	N/A	N/A	N/A
Total Score	**8**	**-4**	**4**	**-9**

Based on this analysis, fiber communications is the most appropriate communications alternative for this project.

Table 12: Final Scoring Matrix Results

Fiber	8
Leased Communications	-4
High-Speed Wireless	4
Low-Speed Wireless	-9

Projects #17, 19, 20, 21

The corridor has the following characteristics:

- Equipped with 1-5 devices per mile
- Monitored by CCTV cameras
- Not along a freeway
- Not along an existing ITS technology corridor
- Not along a planned ITS technology corridor
- Not along a route that has near term construction
- Less than 2 miles from a backbone access point
- More than 2 miles from a BART access point
- Not crossing through an environmentally sensitive area
- No bridge crossings

The scoring matrix results for this project are shown in Table 13.

Table 13: Scoring Matrix of Weighted Values

	Fiber	Leased Comm	High-Speed Wireless	Low-Speed Wireless
< 1 device per mile	N/A	N/A	N/A	N/A
1-5 devices per mile	**-1**	**1**	**-1**	**0**
> 5 devices per mile	N/A	N/A	N/A	N/A
CCTV Cameras	**3**	**1**	**1**	**-3**
Freeway	N/A	N/A	N/A	N/A
Existing ITS Technology Corridor	N/A	N/A	N/A	N/A
Planned ITS Technology Corridor	N/A	N/A	N/A	N/A
Near term construction (less than 24 months)	N/A	N/A	N/A	N/A
Less than 2 miles from Backbone	**3**	**-3**	**2**	**-3**
More than 2 miles from Backbone	N/A	N/A	N/A	N/A
Less than 2 miles from BART	N/A	N/A	N/A	N/A
More than 2 miles from BART	**1**	**1**	**2**	**0**
Environmentally sensitive area	N/A	N/A	N/A	N/A
Bridge crossing	N/A	N/A	N/A	N/A
Total Score	**6**	**0**	**4**	**-6**

Based on this analysis, fiber communications is the most appropriate communications alternative for this project.

Table 14: Final Scoring Matrix Results

Fiber	6
Leased Communications	0
High-Speed Wireless	4
Low-Speed Wireless	-6

Projects #29

The corridor has the following characteristics:

- Equipped with 6devices per mile
- Monitored by CCTV cameras
- Along a freeway
- Not along an existing ITS technology corridor
- Along a planned ITS technology corridor
- Not along a route that has near term construction
- More than 2 miles from a backbone access point
- Less than 2 miles from a BART access point
- Not crossing through an environmentally sensitive area
- Bridge crossing

The scoring matrix results for this project are shown in Table 15.

Table 15: Scoring Matrix of Weighted Values

	Fiber	Leased Comm	High-Speed Wireless	Low-Speed Wireless
< 1 device per mile	N/A	N/A	N/A	N/A
1-5 devices per mile	N/A	N/A	N/A	N/A
> 5 devices per mile	**3**	**0**	**2**	**-3**
CCTV Cameras	**3**	**1**	**1**	**-3**
Freeway	**3**	**-1**	**2**	**3**
Existing ITS Technology Corridor	N/A	N/A	N/A	N/A
Planned ITS Technology Corridor	**3**	**1**	**0**	**-3**
Near term construction (less than 24 months)	N/A	N/A	N/A	N/A
Less than 2 miles from Backbone	N/A	N/A	N/A	N/A
More than 2 miles from Backbone	**1**	**1**	**2**	**0**
Less than 2 miles from BART	**3**	**-3**	**2**	**-3**
More than 2 miles from BART	N/A	N/A	N/A	N/A
Environmentally sensitive area	N/A	N/A	N/A	N/A
Bridge crossing	**-2**	**1**	**2**	**1**
Total Score	**14**	**0**	**11**	**-8**

Based on this analysis, fiber communications is the most appropriate communications alternative for this project.

Table 16: Final Scoring Matrix Results

Fiber	14
Leased Communications	0
High-Speed Wireless	11
Low-Speed Wireless	-8

Projects #30

The corridor has the following characteristics:

- Equipped with 6devices per mile
- Monitored by CCTV cameras
- Along a freeway
- Not along an existing ITS technology corridor
- Not along a planned ITS technology corridor
- Not along a route that has near term construction
- Less than 2 miles from a backbone access point
- More than 2 miles from a BART access point
- Not crossing through an environmentally sensitive area
- Bridge crossing

The scoring matrix results for this project are shown in Table 17.

Table 17: Scoring Matrix of Weighted Values

	Fiber	Leased Comm	High-Speed Wireless	Low-Speed Wireless
< 1 device per mile	N/A	N/A	N/A	N/A
1-5 devices per mile	N/A	N/A	N/A	N/A
> 5 devices per mile	**3**	**0**	**2**	**-3**
CCTV Cameras	**3**	**1**	**1**	**-3**
Freeway	**3**	**-1**	**2**	**3**
Existing ITS Technology Corridor	N/A	N/A	N/A	N/A
Planned ITS Technology Corridor	N/A	N/A	N/A	N/A
Near term construction (less than 24 months)	N/A	N/A	N/A	N/A
Less than 2 miles from Backbone	**3**	**-3**	**2**	**-3**
More than 2 miles from Backbone	N/A	N/A	N/A	N/A
Less than 2 miles from BART	N/A	N/A	N/A	N/A
More than 2 miles from BART	**1**	**1**	**2**	**0**
Environmentally sensitive area	N/A	N/A	N/A	N/A
Bridge crossing	**-2**	**1**	**2**	**1**
Total Score	**11**	**-1**	**11**	**-5**

Based on this analysis, fiber communications tied with High-Speed Wireless the most appropriate communications alternative for this project. In this case fiber communications is considered the most appropriate communications alternative.

Table 18: Final Scoring Matrix Results

Fiber	11
Leased Communications	-1
High-Speed Wireless	11
Low-Speed Wireless	-5

Projects #31, 34

The corridor has the following characteristics:

- Equipped with 6devices per mile
- Monitored by CCTV cameras
- Along a freeway
- Not along an existing ITS technology corridor
- Not along a planned ITS technology corridor
- Not along a route that has near term construction
- Less than 2 miles from a backbone access point
- Less than 2 miles from a BART access point
- Not crossing through an environmentally sensitive area
- Bridge crossings

The scoring matrix results for this project are shown in Table 19.

Table 19: Scoring Matrix of Weighted Values

	Fiber	Leased Comm	High-Speed Wireless	Low-Speed Wireless
< 1 device per mile	N/A	N/A	N/A	N/A
1-5 devices per mile	N/A	N/A	N/A	N/A
> 5 devices per mile	**3**	**0**	**2**	**-3**
CCTV Cameras	**3**	**1**	**1**	**-3**
Freeway	**3**	**-1**	**2**	**3**
Existing ITS Technology Corridor	N/A	N/A	N/A	N/A
Planned ITS Technology Corridor	N/A	N/A	N/A	N/A
Near term construction (less than 24 months)	N/A	N/A	N/A	N/A
Less than 2 miles from Backbone	**3**	**-3**	**2**	**-3**
More than 2 miles from Backbone	N/A	N/A	N/A	N/A
Less than 2 miles from BART	**3**	**-3**	**2**	**-3**
More than 2 miles from BART	N/A	N/A	N/A	N/A
Environmentally sensitive area	N/A	N/A	N/A	N/A
Bridge crossing	**-2**	**1**	**2**	**1**
Total Score	**13**	**-5**	**11**	**-8**

Based on this analysis, fiber communications is the most appropriate communications alternative for this project.

Table 20: Final Scoring Matrix Results

Fiber	13
Leased Communications	-5
High-Speed Wireless	11
Low-Speed Wireless	-8

Projects #32

The existing corridor includes the following characteristics:

- Equipped with 6devices per mile
- Monitored by CCTV cameras
- Along a freeway
- Not along an existing ITS technology corridor
- Not along a planned ITS technology corridor
- Not along a route that has near term construction
- Less than 2 miles from a backbone access point
- Less than 2 miles from a BART access point
- Not crossing through an environmentally sensitive area
- No bridge crossings

The scoring matrix results for this project are shown in Table 21.

Table 21: Scoring Matrix of Weighted Values

	Fiber	Leased Comm	High-Speed Wireless	Low-Speed Wireless
< 1 device per mile	N/A	N/A	N/A	N/A
1-5 devices per mile	N/A	N/A	N/A	N/A
> 5 devices per mile	**3**	**0**	**2**	**-3**
CCTV Cameras	**3**	**1**	**1**	**-3**
Freeway	**3**	**-1**	**2**	**3**
Existing ITS Technology Corridor	N/A	N/A	N/A	N/A
Planned ITS Technology Corridor	N/A	N/A	N/A	N/A
Near term construction (less than 24 months)	N/A	N/A	N/A	N/A
Less than 2 miles from Backbone	**3**	**-3**	**2**	**-3**
More than 2 miles from Backbone	N/A	N/A	N/A	N/A
Less than 2 miles from BART	**3**	**-3**	**2**	**-3**
More than 2 miles from BART	N/A	N/A	N/A	N/A
Environmentally sensitive area	N/A	N/A	N/A	N/A
Bridge crossing	N/A	N/A	N/A	N/A
Total Score	**15**	**-6**	**9**	**-9**

Based on this analysis, fiber communications is the most appropriate communications alternative for this project.

Table 22: Final Scoring Matrix Results

Fiber	15
Leased Communications	-6
High-Speed Wireless	9
Low-Speed Wireless	-9

Projects #33

The corridor has the following characteristics:

- Equipped with 6devices per mile
- Monitored by CCTV cameras
- Along a freeway
- Along an existing ITS technology corridor
- Not along a planned ITS technology corridor
- Not along a route that has near term construction
- More than 2 miles from a backbone access point
- Less than 2 miles from a BART access point
- Environmentally sensitive area
- Bridge crossing

The scoring matrix results for this project are shown in Table 23.

Table 23: Scoring Matrix of Weighted Values

	Fiber	Leased Comm	High-Speed Wireless	Low-Speed Wireless
< 1 device per mile	N/A	N/A	N/A	N/A
1-5 devices per mile	N/A	N/A	N/A	N/A
> 5 devices per mile	**3**	**0**	**2**	**-3**
CCTV Cameras	**3**	**1**	**1**	**-3**
Freeway	**3**	**-1**	**2**	**3**
Existing ITS Technology Corridor	**3**	**2**	**-1**	**-2**
Planned ITS Technology Corridor	N/A	N/A	N/A	N/A
Near term construction (less than 24 months)	N/A	N/A	N/A	N/A
Less than 2 miles from Backbone	N/A	N/A	N/A	N/A
More than 2 miles from Backbone	1	1	2	0
Less than 2 miles from BART	**3**	**-3**	**2**	**-3**
More than 2 miles from BART	N/A	N/A	N/A	N/A
Environmentally sensitive area	**-2**	**2**	**2**	**1**
Bridge crossing	**-2**	**1**	**2**	**1**
Total Score	**12**	**3**	**12**	**-6**

Based on this analysis, fiber communications is the most appropriate communications alternative for this project. In this case fiber communications is considered the most appropriate communications alternative.

Table 24: Final Scoring Matrix Results

Fiber	12
Leased Communications	3
High-Speed Wireless	12
Low-Speed Wireless	-6

Appendix C: Cost Breakdown

Table 1: SHARING FIBER AND CONDUIT INFRASTRUCTURE COSTS

SHARING FIBER AND CONDUIT INFRASTRUCTURE COSTS						
CAPITAL COST						
	Unit Cost		Unit	Quantity		
Equipment Cost						
Fiber Switch and Transceiver	$	5,000	ea	5	$	25,000
Make/test splices and terminations	$	200	ea	72	$	14,400
				TOTAL	**$**	**39,400**
RECCURRING COSTS						
Operation & Maintenance						
Preventative Maintenance*	$	470	per month per mile			
Annual cost (multiply by 12 months)	$	5,640	per year per mile			
25 year cost (multiply by 25 years)	$	141,000	per mile per sharing agreement (25 years)			
Assume agency is responsible for half of the overall operation and maintenance costs of the infrastructure per the sharing agreement	$	70,500	per mile per sharing agreement (25 years)			
TOTAL	**$**	**70,500**	per mile per sharing agreement (25 years)			
Administration						
Cost of Full Time Employee	$	75	per hour			
Assume 5% of a full time employees time per year would be necessary to coordinate sharing agreement	$	7,800	per year			
25 year cost (multiply by 25 years)	$	195,000	per sharing agreement (25 years)			
TOTAL	**$**	**195,000**	per sharing agreement (25 years)			

***Preventative Maintenance**

	Unit Cost		Unit
Preventative maintenance cost along I-880 corridor for 13 months for 220 cabinets	$	890,000	per 13 months per 220 cabinets
Divide by 220 cabinets to get price per cabinet	$	4,050	per 13 months per cabinet
Assume 30% of preventative maintenance is aimed at communications issues	$	1,220	per 13 months per cabinet
Divide by 13 months to get price per month	$	94	per month per cabinet
Assume there are 5 cabinets per mile in a typical urban corridor	$	470	per month per mile

Table 2: SHARING CONDUIT INFRASTRUCTURE COSTS

SHARING CONDUIT INFRASTRUCTURE COSTS						
CAPITAL COST						
	Unit Cost		Unit	Quantity		
Equipment Cost						
Fiber Switch and Transceiver	$	5,000	ea	5	$	25,000
Make/test splices and terminations	$	200	ea	72	$	14,400
Fiber Trunk Cable (72-strand SMFO)	$	8	ft	6000	$	48,000
				TOTAL	**$**	**87,400**
RECCURRING COSTS						
Operation & Maintenance						
Preventative Maintenance*	$	470	per month per mile			
Annual cost (multiply by 12 months)	$	5,640	per year per mile			
25 year cost (multiply by 25 years)	$	141,000	per mile per sharing agreement (25 years)			
Assume agency is responsible for half of the overall operation and maintenance costs of the infrastructure per the sharing agreement	$	70,500	per mile per sharing agreement (25 years)			
TOTAL	**$**	**70,500**	per mile per sharing agreement (25 years)			
Administration						
Cost of Full Time Employee	$	75	per hour			
Assume 5% of a full time employees time per year would be necessary to coordinate sharing agreement	$	7,800	per year			
25 year cost (multiply by 25 years)	$	195,000	per sharing agreement (25 years)			
TOTAL	**$**	**195,000**	per sharing agreement (25 years)			

***Preventative Maintenance**

	Unit Cost		Unit
Preventative maintenance cost along I-880 corridor for 13 months for 220 cabinets	$	890,000	per 13 months per 220 cabinets
Divide by 220 cabinets to get price per cabinet	$	4,050	per 13 months per cabinet
Assume 30% of preventative maintenance is aimed at communications issues	$	1,220	per 13 months per cabinet
Divide by 13 months to get price per month	$	94	per month per cabinet
Assume there are 5 cabinets per mile in a typical urban corridor	$	470	per month per mile

Table 3: FIBER INSTALLATION COSTS

FIBER INSTALLATION COSTS				
CAPITAL COST				
	Unit Cost	Unit	Quantity	
Equipment Cost (1-4” C, ≤ 10 miles)				
1-4” Underground Conduit	$ 60	ft	6000	$ 360,000
Fiber Trunk Cable (72-strand SMFO)	$ 13	ft	6000	$ 78,000
Fiber Pull Boxes	$ 1,200	ea	5	$ 6,000
Termination Panel	$ 800	ea	5	$ 4,000
Fiber Switch and Transceiver	$ 5,000	ea	5	$ 25,000
Make/test splices and terminations	$ 200	ea	72	$ 14,400
Splice Vault	$ 4,000	ea	2	$ 8,000
Splice Closure	$ 2,500	ea	2	$ 5,000
			TOTAL	**$ 500,400**
Equipment Cost (1-4” C, > 10 miles)				
1-4” Underground Conduit	$ 50	ft	6000	$ 300,000
Fiber Trunk Cable (72-strand SMFO)	$ 8	ft	6000	$ 48,000
Fiber Pull Boxes	$ 1,200	ea	5	$ 6,000
Termination Panel	$ 800	ea	5	$ 4,000
Fiber Switch and Transceiver	$ 5,000	ea	5	$ 25,000
Make/test splices and terminations	$ 200	ea	72	$ 14,400
Splice Vault	$ 4,000	ea	2	$ 8,000
Splice Closure	$ 2,500	ea	2	$ 5,000
			TOTAL	**$ 410,400**
Equipment Cost (4-4” C, ≤ 10 miles)				
4-4” Underground Conduit	$ 65	ft	6000	$ 390,000
Fiber Trunk Cable (72-strand SMFO)	$ 13	ft	6000	$ 78,000
Fiber Pull Boxes	$ 1,200	ea	5	$ 6,000
Termination Panel	$ 800	ea	5	$ 4,000
Fiber Switch and Transceiver	$ 5,000	ea	5	$ 25,000
Make/test splices and terminations	$ 200	ea	72	$ 14,400
Splice Vault	$ 4,000	ea	2	$ 8,000
Splice Closure	$ 2,500	ea	2	$ 5,000
Equipment Cost (4-4” C, > 10 miles)				
4-4” Underground Conduit	$ 55	ft	6000	$ 330,000
Fiber Trunk Cable (72-strand SMFO)	$ 8	ft	6000	$ 48,000
Fiber Pull Boxes	$ 1,200	ea	5	$ 6,000
Termination Panel	$ 800	ea	5	$ 4,000
Fiber Switch and Transceiver	$ 5,000	ea	5	$ 25,000
Make/test splices and terminations	$ 200	ea	72	$ 14,400

FIBER INSTALLATION COSTS					
Splice Vault	$	4,000	ea	2	$ 8,000
Splice Closure	$	2,500	ea	2	$ 5,000
				TOTAL	**$ 440,400**
Equipment Cost (1-4" C, Bridge)					
1-4" Underground Conduit	$	80	ft	6000	$ 480,000
Fiber Trunk Cable (72-strand SMFO)	$	8	ft	6000	$ 48,000
Fiber Pull Boxes	$	1,200	ea	5	$ 6,000
Termination Panel	$	800	ea	5	$ 4,000
Fiber Switch and Transceiver	$	5,000	ea	5	$ 25,000
Make/test splices and terminations	$	200	ea	72	$ 14,400
Splice Vault	$	4,000	ea	2	$ 8,000
Splice Closure	$	2,500	ea	2	$ 5,000
				TOTAL	**$ 590,400**
Operation & Maintenance					
Preventative Maintenance*	$	470	per month per mile		
Annual cost (multiply by 12 months)	$	5,640	per year per mile		
25 year cost (multiply by 25 years)	$	141,000	per mile per sharing agreement (25 years)		
TOTAL	**$**	**141,000**			
Operation & Maintenance (Bridge Only)					
Preventative Maintenance*	$	700	per month per mile		
Annual cost (multiply by 12 months)	$	8,400	per year per mile		
25 year cost (multiply by 25 years)	$	210,000	per mile per sharing agreement (25 years)		
TOTAL	**$**	**210,000**			
TOTAL	**$**	**210,000**			

***Preventative Maintenance**	Unit Cost	Unit
Preventative maintenance cost along I-880 corridor for 13 months for 220 cabinets	$ 890,000	per 13 months per 220 cabinets
Divide by 220 cabinets to get price per cabinet	$ 4,050	per 13 months per cabinet
Assume 30% of preventative maintenance is aimed at communications issues	$ 1,220	per 13 months per cabinet
Divide by 13 months to get price per month	$ 94	per month per cabinet
Assume there are 5 cabinets per mile in a typical urban corridor	$ 470	per month per mile

Appendix D: Project Cost Calculation Example

Equation A. Sharing Conduit and Fiber Infrastructure Example

X = length of project (in miles)

Construction Cost (CC) = $39,400/mile * X

PE cost = 0.15 * CC

Total Project Cost = Construction Cost + PE cost + O&M (for 25 years) + Admin (for 25 years)

Equation B. Sharing Conduit Infrastructure Example on Bridge

X = length of project (in miles)

Construction Cost (CC) = $87,400/mile * X

PE cost = 0.5 * CC

Systems Integration = 0.02*CC

Total Project Cost = Construction Cost + PE cost + Systems Integration cost + O&M (for 25 years) + Admin (for 25 years)

Equation C. Installing Fiber Infrastructure Example Along Freeway (less than 10 miles)

X = length of project (in miles)

Construction Cost (CC) = $530,400/mile * X

PE cost = 0.3 * CC

Systems Integration = 0.02*CC

Hub Equipment = $15,000/mile * X (only applicable to projects along fiber backbone)

R/W cost = 0.005 * CC

Traffic Control = 0.5*CC

Misc. Construction = 0.2*CC

Total Project Cost = Construction Cost + PE cost + R/W cost + Systems Integration cost + Hub Equipment cost + Traffic Control cost + Misc. Construction cost + O&M (for 25 years)

Equation D. Installing Fiber Infrastructure Example Along Freeway (more than 10 miles)

X = length of project (in miles)

Construction Cost (CC) = $440,400/mile * X

PE cost = 0.3 * CC

Systems Integration = 0.02*CC

Hub Equipment = $15,000/mile * X (only applicable to projects along fiber backbone)

R/W cost = 0.005 * CC

Traffic Control = 0.5*CC

Misc. Construction = 0.2*CC

Total Project Cost = Construction Cost + PE cost + R/W cost + Systems Integration cost + Hub Equipment cost + Traffic Control cost + Misc. Construction cost + O&M (for 25 years)

Equation E. Installing Fiber Infrastructure Example Along Local Roads (less than 10 miles)

X = length of project (in miles)

Construction Cost (CC) = $500,400/mile * X

PE cost = 0.3 * CC

Systems Integration = 0.02*CC

Hub Equipment = $15,000/mile * X (only applicable to projects along fiber backbone)

R/W cost = 0.01 * CC

Traffic Control = 0.5*CC

Misc. Construction = 0.2*CC

Total Project Cost = Construction Cost + PE cost + R/W cost + Systems Integration cost + Hub Equipment cost + Traffic Control cost + Misc. Construction cost + O&M (for 25 years)

Equation F. Installing Fiber Infrastructure Example Along Local Roads (more than 10 miles)

X = length of project (in miles)

Construction Cost (CC) = $410,400/mile * X

PE cost = 0.3 * CC

Systems Integration = 0.02*CC

Hub Equipment = $15,000/mile * X (only applicable to projects along fiber backbone)

R/W cost = 0.01 * CC

Traffic Control = 0.5*CC

Misc. Construction = 0.2*CC

Total Project Cost = Construction Cost + PE cost + R/W cost + Systems Integration cost + Hub Equipment cost + Traffic Control cost + Misc. Construction cost + O&M (for 25 years)

Equation G. Installing Fiber Infrastructure Example on Bridge

X = length of project (in miles)

Construction Cost (CC) = $590,400/mile * X

PE cost = 0.5 * CC

Systems Integration = 0.02*CC

Total Project Cost = Construction Cost + PE cost + Systems Integration + O&M (for 25 years)

The table below shows the length of each project and which equation was used to calculate its cost.

Table 1: PROJECT LEGNTH AND CORRESPODING COST EQUATION

Project	Project Length (miles)	Equation Used
VTA/Caltrans to dedicate fiber strands installed as part of the planned SR 237 Express Lane project for regional communications purposes	2	A
VTA/Caltrans to dedicate fiber strands installed as part of the planned US 101 Express Lane Project for regional communications purposes	11	A
C/CAG/Caltrans to dedicate fiber strands installed as part of the planned US 101 Managed Lanes Project for regional communications purposes	23	A
Install communications infrastructure along US 101 from Grand Avenue, South San Francisco to I-80	8	C
Install communications infrastructure along I-80 from US 101 to Yerba Buena Island	4	G
Caltrans to make existing conduit infrastructure available for regional communications purposes along I-80 from Yerba Buena Island to Bay Bridge Toll Plaza	4	B
Install communications infrastructure along I-80 and I-880 from the Bay Bridge Toll Plaza to Hegenberger Road	10	C
BAIFA/Caltrans to dedicate existing fiber strands along I-880 from Hegenberger Road to Dixon Landing Road	26	A
Install communications infrastructure along I-880 from Dixon Landing Road to SR 237	2	C
Install communications infrastructure along SR 237 from I-880 to North 1st Street	2	C
Connect Digital Realty data center (Oakland) to nearest regional communications network connection point (I-880, Webster Street interchange)	0.6	E
Connect Digital Realty data center (San Francisco) to nearest regional communications network connection point (US 101, 3rd Street interchange)	0.6	E
County of Santa Clara to dedicate existing fiber strands for regional communications purposes to connect Digital Realty data center (San Jose) to nearest regional communications network point (SR 237, Lawrence Expressway interchange)	4	E
City of San Jose to dedicate existing fiber strands for regional communications purposes to connect VTA headquarters (San Jose) to nearest regional communications network point (SR 237, Zanker Road interchange)	7	A
Connect AC Transit headquarters (Oakland) to nearest regional communications network connection point (I-880, Broadway interchange)	0.7	E
Connect SFMTA headquarters (San Francisco) to nearest regional communications network connection point (US 101/I-80 interchange)	0.1	E
Connect Samtrans/Caltrain headquarters (San Carlos) to nearest regional communications network connection point (US 101, Holly Street interchange)	0.8	E
Connect BART headquarters (Oakland) to nearest regional communications network connection point (I-880, Broadway interchange)	1	E
Connect WestCAT headquarters (Pinole) to nearest regional communications network connection point (I-80, Appian Way interchange)	2	E

Project	Project Length (miles)	Equation Used
Connect LAVTA headquarters (Livermore) to nearest regional communications network connection point (I-580, Isabel Avenue interchange)	0.9	E
Connect SolTrans headquarters (Vallejo) to nearest regional communications network connection point (I-80, Carquinez Bridge)	3	E
City of San Jose to dedicate existing fiber strands for regional communications purposes to connect City of San Jose TMC to nearest regional communications network connection point (SR 237, Zanker Road interchange)	7	E
Connect City of San Francisco TMC to nearest regional communications network connection point (US 101/I-80 interchange)	0.1	A
City of Fremont to dedicate existing fiber strands for regional communications purposes to connect City of Fremont TMC to nearest regional communications network connection point (I-880, Mowry Avenue interchange)	2	E
Connect City of Oakland TMC to nearest regional communications network connection point (I-880, Broadway interchange)	0.6	E
Caltrans to dedicate planned fiber strands for regional communications purposes to connect Caltrans D4 office to regional communications network connection (I-80, Bay Bridge Toll Plaza)	4	E
Create redundant loop for the regional communications network across the San Mateo Bridge	11 (total) 7 (share conduit with Caltrans) 4 (install fiber communications)	B+C
Create redundant loop for the regional communications network across the Dumbarton Bridge	8 (total) 6 (share conduit with Caltrans) 2 (install fiber communications)	B+C
Install communications infrastructure to connect STA I-80 express lanes to nearest regional communications network connection point (Carquinez Bridge) along I-80 from SR 12 to Carquinez Bridge	15	D
Install communications infrastructure to connect SR 37 managed lanes to nearest regional communications network connection point (I-80) along SR 37 from Railroad Avenue to I-80	5	C
Install communications infrastructure to nearest regional communications network connection point (I-880/SR 238 interchange) along I-580 from I-680 to SR 238 and along SR 238 from I-580 to the I-880	12	D
Install communications infrastructure to connect Sunol express lanes to nearest regional communications network connection point (I-880/SR 262 interchange) along SR 262 from I-680 to I-880	1	C
Install communications infrastructure along the Carquinez Bridge	2	G
Install communications infrastructure along I-80 from the Carquinez bridge to I-580	18	D
City of San Jose to dedicate existing fiber strands for regional communications purposes to connect SR 85 express lanes to nearest regional fiber network connection point (I-880, Zanker Road interchange)	14	E
City of Dublin to dedicate existing fiber strands for regional communications purposes to connect City of Dublin TMC to nearest regional fiber network connection point (I-580, San Ramon Road interchange)	2	E

Appendix E: Return on Investment Assumptions

The four tables below outline the cost of leasing wireless and installing fiber per existing and future conditions. They are followed by a list of assumptions.

Table 1: Scenario A - Leased Wireless, Existing, 6 devices per mile, 1 mile sample corridor

Assumptions						
Contents of cabinet: 2070E controller, modem, antenna, cabling						
Existing TMS - 6 devices per mile (2 RM, 2 VDS, 1 CMS, 1 CCTV)						
1 multi-device cabinet, 4 single-device cabinets (5 cabinets total)						
		Unit Cost	**Unit**	**Quantity**		**Line Item Total**
Capital Cost (Furnish/Install)						
Wireless Modem	$	1,500	ea	5	$	7,500
Antenna	$	500	ea	5	$	2,500
Misc. Cabling	$	500	ea	5	$	2,500
Capital Cost (Initial Leased Line Cost)						
Start-Up Cost	$	500	ea	6	$	3,000
				TOTAL CAPITAL COST (Year 1)	**$**	**15,500**
Monthly Maintenance Costs						
Corrective Maintenance - Communications Equipment Repair*	$	400	per month	12	$	4,800
Preventative Maintenance**	$	470	per month	12	$	5,640
Monthly Recurring Costs						
Cellular Service (6 Devices - 2 RM, 2 VDS, 1 CMS, 1 CCTV)	$	270	per month	12	$	3,420
				TOTAL ANNUAL COST	**$**	**27,040**

Table 2: Scenario B - Fiber, Existing, 6 devices per mile, 1 mile sample corridor

Assumptions				
Contents of cabinet: 2070E controller, termination panel, fiber switch				
Existing TMS - 6 devices per mile (2 RM, 2 VDS, 1 CMS, 1 CCTV)				
1 multi-device cabinet, 4 single-device cabinets (5 cabinets total)				
Capital Cost (Furnish/Install)	**Unit Cost**	**Unit**	**Quantity**	**Line Item Total**
4" Underground Conduit	$ 55	ft	7500	$ 412,500
Fiber Trunk Cable (72-strand SMFO)	$ 8	ft	6000	$ 48,000
Fiber Branch Cable (12-strand SMFO)	$ 4	ft	1500	$ 6,000
Termination Panel	$ 800	ea	5	$ 4,000
Fiber Switch and Transceiver	$ 5,000	ea	5	$ 25,000
Make/test splices and terminations	$ 200	ea	72	$ 14,400
Splice Vault	$ 4,000	ea	2	$ 8,000
Splice Closure	$ 2,500	ea	2	$ 5,000
Fiber Pull Boxes	$ 1,200	ea	5	$ 6,000
Hub Equipment	$ 15,000	mile	1	$ 15,000
Engineering and Initial Construction Costs				
Preliminary Engineering	$ 163,170	mile	1	$ 163,170
R/W Cost	$ 2,719	mile	1	$ 2,719
Traffic Control	$ 271,950	mile	1	$ 271,950
Misc. Construction	$ 108,780	mile	1	$ 108,780
Systems Integration and Testing	$ 10,878	mile	1	$ 10,878
			TOTAL CAPITAL COST (Year 1)	**$ 1,101,367**
Monthly Maintenance Costs				
Corrective Maintenance	N/A	per month	12	$ 0
Preventative Maintenance**	$ 470	per month	12	$ 5,640
Monthly Recurring Costs				
	N/A	per month	12	$ 0
			TOTAL ANNUAL COST	**$ 5,640**

Table 3: Scenario A - Leased Wireless, Future, 21 devices per mile, 1 mile sample corridor

Assumptions						
Contents of cabinet: 2070E controller, modem, antenna, cabling						
Existing TMS - 6 devices per mile (2 RM, 2 VDS, 1 CMS, 1 CCTV)						
Express Lanes - 8 additional devices per mile (2 electronic toll signs, 2 toll readers, 4 license plate reader cameras)						
CV/AV - 2 additional devices per mile (2 DSRC radios)						
HOV Enforcement - 5 additional devices per mile (2 VOD cameras, 2 near-infrared flashes, 1 laser trigger)						
7 multi-device cabinets, 5 single-device cabinets (12 cabinets total)						
		Unit Cost	**Unit**	**Quantity**		**Line Item Total**
Capital Cost (Furnish/Install)						
Wireless Modem	$	1,500	ea	12	$	18,000
Antenna	$	500	ea	12	$	6,000
Misc. Cabling	$	500	ea	12	$	6,000
Capital Cost (Initial Leased Line Cost)						
Start-Up Cost	$	500	ea	21	$	10,500
				TOTAL CAPITAL COST (Year 1)	**$**	**40,500**
Monthly Maintenance Costs						
Corrective Maintenance - Communications Equipment Repair***	$	950	per month	12	$	11,400
Preventative Maintenance****	$	1,130	per month	12	$	13,560
Monthly Recurring Costs						
Cellular Service (15 Devices - 2 RM, 2 VDS, 1 CMS, 1 CCTV device, 2 electronic toll signs, 2 toll readers, 2 DSRC radios, 2 near-infrared flashes, 1 laser trigger)	$	675	per month	12	$	8,100
ASE Line (6 Devices - 4 license plate reader cameras, 2 VOD cameras)	$	2,400	per month	12	$	28,800
				TOTAL ANNUAL COST	**$**	**61,860**

Table 4: Scenario B - Fiber, Future, 21 devices per mile, 1 mile sample corridor

Assumptions					
Contents of cabinet: 2070E controller, modem, antenna, cabling					
Existing TMS - 6 devices per mile (2 RM, 2 VDS, 1 CMS, 1 CCTV)					
Express Lanes - 8 additional devices per mile (2 electronic toll signs, 2 toll readers, 4 license plate reader cameras)					
CV/AV - 2 additional devices per mile (2 DSRC radios)					
HOV Enforcement - 5 additional devices per mile (2 VOD cameras, 2 near-infrared flashes, 1 laser trigger)					
7 multi-device cabinets, 5 single-device cabinets (12 cabinets total)					
Contents of cabinet: 2070E controller, modem, antenna, cabling					
Capital Cost (Furnish/Install)	**Unit Cost**	**Unit**	**Quantity**	**Line Item Total**	
4" Underground Conduit	$ 55	ft	9600	$	528,000
Fiber Trunk Cable (72-strand SMFO)	$ 8	ft	6000	$	48,000
Fiber Branch Cable (12-strand SMFO)	$ 4	ft	3600	$	14,400
Termination Panel	$ 800	ea	12	$	9,600
Fiber Switch and Transceiver	$ 5,000	ea	12	$	60,000
Make/test splices and terminations	$ 200	ea	72	$	14,400
Splice Vault	$ 4,000	ea	2	$	8,000
Splice Closure	$ 2,500	ea	2	$	5,000
Fiber Pull Boxes	$ 1,200	ea	12	$	14,400
Hub Equipment	$ 15,000	mile	1	$	15,000
Engineering and Initial Construction Costs					
Preliminary Engineering	$ 215,040	mile	1	$	215,040
R/W Cost	$ 3,584	mile	1	$	3,584
Traffic Control	$ 358,400	mile	1	$	358,400
Misc. Construction	$ 143,360	mile	1	$	143,360
Systems Integration and Testing	$ 14,336	mile	1	$	14,336
		TOTAL CAPITAL COST (Year 1)		**$**	**1,101,367**

Table 4 Continued on Next Page

Continuation of Table 4 from Previous Page

Monthly Maintenance Costs					
Corrective Maintenance		N/A	per month	12	$ 0
Preventative Maintenance****	$	470	per month	12	$ 5,640
Monthly Recurring Costs					
		N/A	per month	12	$ 0
				TOTAL ANNUAL COST	**$ 5,640**

**Scenario A - Wireless Corrective Maintenance (Existing)*

Corrective maintenance cost along I-880 corridor for 13 months for 220 cabinets	$ 740,000
Divide by 220 cabinets to get price per cabinet	$ 3,370
Around 30% of tickets are communications issues	$ 1,020
Divide by 13 months to get price per month	$ 789
Multiply by 5 cabinets	$ 400

***Preventative Maintenance (Existing)*

	Unit Cost	Unit
Preventative maintenance cost along I-880 corridor for 13 months for 220 cabinets	$ 890,000	per 13 months per 220 cabinets
Divide by 220 cabinets to get price per cabinet	$ 4,050	per 13 months per cabinet
Assume 30% of preventative maintenance is aimed at communications issues	$ 1,220	per 13 months per cabinet
Divide by 13 months to get price per month	$ 94	per month per cabinet
Assume there are 5 cabinets per mile in a typical urban corridor	$ 470	per month per mile

****Scenario A - Wireless Corrective Maintenance (Future)*

Corrective maintenance cost along I-880 corridor for 13 months for 220 cabinets	$ 740,000
Divide by 220 cabinets to get price per cabinet	$ 3,370
Around 30% of tickets are communications issues	$ 1,020
Divide by 13 months to get price per month	$ 79
Multiply by 12 cabinets	$ 950.

*****Preventative Maintenance (Future)*

Preventative maintenance cost along I-880 corridor for 13 months for 220 cabinets	$ 890,000
Divide by 220 cabinets to get price per cabinet	$ 4,050
Assume 30% of preventative maintenance is aimed at communications issues	$ 1,220
Divide by 13 months to get price per month	$ 94
Multiply by 12 cabinets	$ 1,130

Additional Assumptions:

- See figures in Section 5.1.3 for illustrations of the four scenarios discussed.
- Future Scenario A - Assume license plate reader and VOD cameras will be use ASE circuit leased line communications in the future. The assumed cost is $400/device/month for 2 high-bandwidth streams per camera.
- All scenarios assume a 3% annual inflation rate
- All leased wireless scenarios assume an additional 4% annual inflation (7% annual inflation rate total) due to fluctuation in pricing for a third party service. Fiber infrastructure is assumed to be agency-owned which is not affected by third-party price increases.
- The table below shows the lifespan assumed for each device.

Table 1: Assumed Lifespan for Devices

Equipment	Years
Wireless Modem	5
Antenna	5
Misc. Cabling	5
Fiber Trunk Cable	20
Termination Panel	20
Fiber Switch	8

Appendix F: Available Funding Sources by Project

ID No.	Project	Regional	State	Federal	Total Number of Available Funding Sources
1	VTA/Caltrans to dedicate fiber strands installed as part of the planned SR 237 Express Lane project for regional communications purposes	* Regional Measure 3	* Senate Bill 1 * State Transportation Improvement Plan	* Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	5
2	VTA/Caltrans to dedicate fiber strands installed as part of the planned US 101 Express Lane Project for regional communications purposes	* Regional Measure 3	* Senate Bill 1 * State Transportation Improvement Plan	* Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	5
3	C/CAG/Caltrans to dedicate fiber strands installed as part of the planned US 101 Managed Lanes Project for regional communications purposes		* Senate Bill 1 * State Transportation Improvement Plan	* Surface Transportation Block Grant Program * Better Utilizing Investments to Leverage Development * Transportation Infrastructure Finance and Innovation Act	5
4	Install communications infrastructure along US 101 from Grand Avenue, South San Francisco to I-80	* Urban Areas Security Initiative		* Surface Transportation Block Grant Program * Better Utilizing Investments to Leverage Development * Transportation Infrastructure Finance and Innovation Act	4
5	Install communications infrastructure along I-80 from US 101 to Yerba Buena Island	* Urban Areas Security Initiative * Lifeline Transportation Program	* Active Transportation Program	* Surface Transportation Block Grant Program * Better Utilizing Investments to Leverage Development * Transportation Infrastructure Finance and Innovation Act	6
6	Caltrans to make existing conduit infrastructure available for regional communications purposes along I-80 from Yerba Buena Island to Bay Bridge Toll Plaza	* Lifeline Transportation Program	* Active Transportation Program	* Surface Transportation Block Grant Program * Better Utilizing Investments to Leverage Development * Transportation Infrastructure Finance and Innovation Act	5
7	Install communications infrastructure along I-80 and I-880 from the Bay Bridge Toll Plaza to Hegenberger Road	* Urban Areas Security Initiative		* Surface Transportation Block Grant Program * Better Utilizing Investments to Leverage Development * Transportation Infrastructure Finance and Innovation Act	4
8	BAIFA/Caltrans to dedicate existing fiber strands along I-880 from Hegenberger Road to Dixon Landing Road		* Senate Bill 1 * State Transportation Improvement Plan	* Transportation Infrastructure Finance and Innovation Act	3
9	Install communications infrastructure along I-880 from Dixon Landing Road to SR 237	* Urban Areas Security Initiative		* Surface Transportation Block Grant Program * Better Utilizing Investments to Leverage Development * Transportation Infrastructure Finance and Innovation Act	4
10	Install communications infrastructure along SR 237 from I-880 to North 1st Street	* Urban Areas Security Initiative		* Surface Transportation Block Grant Program * Better Utilizing Investments to Leverage Development * Transportation Infrastructure Finance and Innovation Act	4

ID No.	Project	Regional	State	Federal	Total Number of Available Funding Sources
11	Connect Digital Realty data center (Oakland) to nearest regional communications network connection point (I-880, Webster Street interchange)	* Urban Areas Security Initiative		* Surface Transportation Block Grant Program * Better Utilizing Investments to Leverage Development * Transportation Infrastructure Finance and Innovation Act	4
12	Connect Digital Realty data center (San Francisco) to nearest regional communications network connection point (US 101, 3rd Street interchange)	* Urban Areas Security Initiative		* Surface Transportation Block Grant Program * Better Utilizing Investments to Leverage Development * Transportation Infrastructure Finance and Innovation Act	4
13	County of Santa Clara to dedicate existing fiber strands for regional communications purposes to connect Digital Realty data center (San Jose) to nearest regional communications network point (SR 237, Lawrence Expressway interchange)	* Urban Areas Security Initiative		* Surface Transportation Block Grant Program * Better Utilizing Investments to Leverage Development* Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	5
14	City of San Jose to dedicate existing fiber strands for regional communications purposes to connect VTA headquarters (San Jose) to nearest regional communications network point (SR 237, Zanker Road interchange)	* Urban Areas Security I Initiative		* Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	3
15	Connect AC Transit headquarters (Oakland) to nearest regional communications network connection point (I-880, Broadway interchange)	* Urban Areas Security Initiative		* Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	3
16	Connect SFMTA headquarters (San Francisco) to nearest regional communications network connection point (US 101/I-80 interchange)	* Urban Areas Security Initiative		* Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	3
17	Connect Samtrans/Caltrain headquarters (San Carlos) to nearest regional communications network connection point (US 101, Holly Street interchange)	* Urban Areas Security Initiative		* Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	3
18	Connect BART headquarters (Oakland) to nearest regional communications network connection point (I-880, Broadway interchange)	* Urban Areas Security Initiative		* Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	3
19	Connect WestCAT headquarters (Pinole) to nearest regional communications network connection point (I-80, Appian Way interchange)	* Urban Areas Security Initiative		* Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	3

ID No.	Project	Regional	State	Federal	Total Number of Available Funding Sources
20	Connect LAVTA headquarters (Livermore) to nearest regional communications network connection point (I-580, Isabel Avenue interchange)	* Urban Areas Security Initiative	* CPUC California Advanced Services Fund	* Surface Transportation Block Grant Program * Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	4
21	Connect SolTrans headquarters (Vallejo) to nearest regional communications network connection point (I-80, Carquinez Bridge)	* Urban Areas Security Initiative		* Surface Transportation Block Grant Program * Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	4
22	City of San Jose to dedicate existing fiber strands for regional communications purposes to connect City of San Jose TMC to nearest regional communications network connection point (SR 237, Zanker Road interchange)	* Urban Areas Security Initiative	* CPUC California Advanced Services Fund	* Surface Transportation Block Grant Program * Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	5
23	Connect City of San Francisco TMC to nearest regional communications network connection point (US 101/I-80 interchange)	* Urban Areas Security Initiative		* Surface Transportation Block Grant Program * Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	5
24	City of Fremont to dedicate existing fiber strands for regional communications purposes to connect City of Fremont TMC to nearest regional communications network connection point (I-880, Mowry Avenue interchange)	* Urban Areas Security Initiative		* Surface Transportation Block Grant Program * Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	4
25	Connect City of Oakland TMC to nearest regional communications network connection point (I-880, Broadway interchange)	* Urban Areas Security Initiative		* Surface Transportation Block Grant Program * Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	4
26	Caltrans to dedicate planned fiber strands for regional communications purposes to connect Caltrans D4 office to regional communications network connection (I-80, Bay Bridge Toll Plaza)	* Urban Areas Security Initiative		* Surface Transportation Block Grant Program * Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	4
27	Create redundant loop for the regional communications network across the San Mateo Bridge	* Urban Areas Security Initiative * Lifeline Transportation Program	* Active Transportation Program	* Surface Transportation Block Grant Program * Better Utilizing Investments to Leverage Development * Transportation Infrastructure Finance and Innovation Act	6

ID No.	Project	Regional	State	Federal	Total Number of Available Funding Sources
28	Create redundant loop for the regional communications network across the Dumbarton Bridge	* Urban Areas Security Initiative * Lifeline Transportation Program	* Active Transportation Program	* Surface Transportation Block Grant Program * Better Utilizing Investments to Leverage Development * Transportation Infrastructure Finance and Innovation Act	6
29	Install communications infrastructure to connect STA I-80 express lanes to nearest regional communications network connection point (Carquinez Bridge) along I-80 from SR 12 to Carquinez Bridge	* Regional Measure 3	* Senate Bill 1 * State Transportation Improvement Plan	* Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	5
30	Install communications infrastructure to connect SR 37 managed lanes to nearest regional communications network connection point (I-80) along SR 37 from Railroad Avenue to I-80		* Senate Bill 1 * State Transportation Improvement Plan	* Surface Transportation Block Grant Program * Better Utilizing Investments to Leverage Development * Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	6
31	Install communications infrastructure to nearest regional communications network connection point (I-880/SR 238 interchange) along I-580 from I-680 to SR 238 and along SR 238 from I-580 to the I-880	* Regional Measure 3	* Senate Bill 1 * State Transportation Improvement Plan	* Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	5
32	Install communications infrastructure to connect Sunol express lanes to nearest regional communications network connection point (I-880/SR 262 interchange) along SR 262 from I-680 to I-880	* Regional Measure 3	* Senate Bill 1 * State Transportation Improvement Plan	* Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	5
33	Install communications infrastructure along the Carquinez Bridge	* Urban Areas Security Initiative * Lifeline Transportation Program	* Active Transportation Program	* Surface Transportation Block Grant Program * Better Utilizing Investments to Leverage Development * Transportation Infrastructure Finance and Innovation Act	6
34	Install communications infrastructure along I-80 from the Carquinez bridge to I-580	* Urban Areas Security Initiative		* Surface Transportation Block Grant Program * Better Utilizing Investments to Leverage Development * Transportation Infrastructure Finance and Innovation Act	4
35	City of San Jose to dedicate existing fiber strands for regional communications purposes to connect SR 85 express lanes to nearest regional fiber network connection point (I-880, Zanker Road interchange)		* Senate Bill 1 * State Transportation Improvement Plan	* Surface Transportation Block Grant Program * Better Utilizing Investments to Leverage Development * Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	6
36	City of Dublin to dedicate existing fiber strands for regional communications purposes to connect City of Dublin TMC to nearest regional fiber network connection point (I-580, San Ramon Road interchange)	* Urban Areas Security Initiative		* Surface Transportation Block Grant Program * Transportation Infrastructure Finance and Innovation Act * Advanced Transportation and Congestion Management Technologies Deployment	4